JUN 16 1925

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See page 38.
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See Advertisement, page 43. 2584

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See Advertisement page 62, May 29. 2402

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See Full Page Advt., page 58, May 22.

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See Advert., page 95, May 22. 3195

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Notice is Hereby Given that

the Senate will PROCEED to ELECT EXTERNAL EXAMINERS for the calendar year 1926 for the Examinations above Matriculation, as follows. Except when otherwise stated, Examiners will act in all Examinations in which the subject is included.

For the Calendar Year 1926.

Engineering, Civil and Mechanical (Two).

Engineering Drawing and Design.

N.B.—Attention is drawn to the provision of Statute 124, whereby the Senate is required if practicable, to appoint at least one Examiner who is not a Teacher of the University.

Application Form (or Forms if more than one Examinership is applied for) and particulars of the remuneration and duties can be obtained from the External Registrar.

Candidates must send in their names to the External Registrar, GEO. F. GOODCHILD, M.A. B Sc., with any attestation of their qualifications they may think desirable, on or before Monday, 6 July, 1925. (Envelopes should be marked "Examinership.")

The Senate desire that no application of any kind be made to individual members.

If testimonials are submitted, one copy only of each is required. In no case should original testimonials be submitted. If more than one Examinership is applied for, a separate and complete application must be forwarded in respect of each Examinership. The appointments will be made by the re ate in November. Applicants who desire that the result should be communicated to them are requested to enclose a stamped and addressed envelope with their applications.

E. C. PERRY,
Principal Officer.

University of London,
South Kensington,
S.W. 7.
June, 1925. J 215

ROYAL AIRCRAFT ESTABLISHMENT.

An Examination for the

Entry of TEN TRADE LADS to the above Establishment will be held on Tuesday, 23rd June, 1925. Application for admission to the examination must be made on the prescribed form, which must be filled in and returned not later than Wednesday, 17th June.

Application forms and the regulations governing the conditions of entry and training of Trade Lads may be obtained by post from

THE SUPERINTENDENT,
Royal Aircraft Establishment,
South Farnborough,
Hants.

or by personal application at the R.A.E. Employment Department. J 180

Correspondence Courses for

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Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship

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TENDERS.

METROPOLITAN ASYLUMS BOARD.

TO HEATING ENGINEERS AND OTHERS.

The Board invite

Tenders for the Supply and

DELIVERY of a STEAM HEATED HOT WATER CALORIFIER, to Tooting Bec Hospital, Tooting Bec Road, S.W.17, in accordance with the Specification and Drawing prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawing and Form of Tender may be inspected at the Office of the Board, Victoria Embankment E.C.4, on and after Ten a.m., on Monday, June 1, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawing have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, June 17, 1925.

G. A. POWELL,
Clerk to the Board. J 203

THE DUBLIN PORT AND DOCKS BOARD is prepared to receive

Tenders for the Supply and

DELIVERY at Port Stores, East Wall, Dublin, of TWO 13 ft. RAIL WAGON TURNTABLES.

Particulars may be obtained on application to the Engineer's Office, East Wall, Dublin.

Sealed Tenders endorsed on the outside "Turntables" must be delivered to the SECRETARY, Dublin Port and Docks Board, Westmoreland Street, Dublin, not later than Eleven a.m., on Wednesday, 24th June, 1925.

The Board does not bind itself to accept the lowest or any Tender.

Port and Docks Office.
2nd June, 1925. J 218

GREAT WESTERN RAILWAY.

The Directors of this Company are prepared to receive

Tenders for the Purchase of a

STEAM PLANT comprising one 310 K.V.A. Turbo Alternator, two 410 K.V.A. Turbo Alternators complete with Switchboard and Switchgear, four Lancashire Boilers with Superheaters and Feed Pumps, at their Generating Station, Swansea Harbour.

Forms of Tender and particulars may be obtained on application to the undersigned by whom Tenders marked outside "Tender for Plant, Swansea," will be received not later than Ten a.m. on Friday, the 19th proximo.

The Directors do not bind themselves to accept the highest or any Tender.

A. E. BOLTER,
Secretary.

Paddington Station,
London, W. 2.
26th May, 1925. J 214

HAWARDEN RURAL DISTRICT COUNCIL.

ELECTRICITY UNDERTAKING.

Tenders are Invited for the

SUPPLY and LAYING of LOW TENSION UNDERGROUND CABLES and FITTINGS.

Copies of Specification, General Conditions, and Form of Tender obtainable from the undersigned upon payment of a deposit of £1 1s. returnable after receipt of a *bona fide* Tender.

Tenders must be received by me not later than Twelve noon on Thursday, the 11th June, prox.

By Order,
ARNOLD K. WROE,
Clerk to the Council.

Council Offices,
Broughton, Nr. Chester.
May 27th, 1925. J 189

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :—

1. HELICAL and VOLUTE SPRINGS.
2. STEEL DRAWBARS for Wagons.
3. SPARE PARTS of CARRIAGES and WAGONS.
4. STRUCTURAL STEELWORK (Millwright and Electrical Shop).
5. Ditto, ditto (Erecting and Coppersmith Shop).

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Springs," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 19th June, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5/- for each copy of Specifications Nos. 1 and 2, and of 10/- for each copy of Specifications Nos. 3 and 4, and of £1 for each copy of Specification No. 5.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, of 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, Westminster, S.W.1.
2nd June, 1925. J 231

By Order of the Receiver for Debenture Holders,
C. J. PAIN, Esq., F.C.A., J.P.
MESSRS. CUTTING BROS.,
PARK WORKS,
STAMFORD.

HENRY BUTCHER & CO.
have received instructions to offer

For Sale by Tender, as Going

CONCERN,
the Old-established
ELECTRICAL ENGINEERING WORKS
MANUFACTURING ELECTRIC MOTORS,
GENERATORS, &c.

The Works are in full operation, with orders in hand, and with Works and Office Staff which could be retained.

The PROPERTY is FREEHOLD, has a site area of four acres, and comprises Workshops and Foundry with clear floor space of about 34,500 sq. ft., Offices, Yard and Land for extension adjoining the London, Midland and Scottish Railway.

The SHOPS, IRON and BRASS FOUNDRIES are fully equipped with modern plant and machinery.

Included with the assets are
COMPLETE WORKING DRAWINGS and PATTERNS
for Motors and Generators up to 110 Kw., Polishing Lathes, etc.
STOCK, STORES, FURNITURE and all EQUIPMENT.
GOODWILL.

The Works may be inspected between the hours of Ten a.m. and Four p.m., from MONDAY, JUNE 22nd, to FRIDAY, JUNE 26th, inclusive.

Tender Forms (when ready), and full particulars, can be obtained from :—

Messrs. HUBBART, DUROSE & PAIN, Chartered Accountants, 18, Low Pavement, Nottingham, and 46, Holborn Viaduct, London, E.C.1.

Messrs. HENRY BUTCHER & CO., Engineering Auctioneers, Valuers and Surveyors, 63 and 64, Chancery Lane, London, W.C.2. J 235

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 26th June,

Tenders for the Supply of

GIRDER BRIDGES.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 20s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices, 91, Petty France,
Westminster, S.W.1.
3rd June, 1925. J 232

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C., invite

Tenders for :—

		s. d.
1. MISCELLANEOUS ARTICLES and MATERIALS	Fee	10 0
2. LEATHER HIDES, &c.	"	5 0
3. CARRIAGE DOOR HANDLES, HINGES, &c....	"	5 0
4. CARRIAGE FITTINGS	"	7 6
5. BIB COCKS, &c.	"	2 6

Tender forms are due by Eleven a.m., on 16th June, 1925. Tender forms obtainable at above address. Fees not returnable. J 243

HEATING.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive

Tenders before Eleven

a.m., on Friday, 19th June, 1925, for LOW PRESSURE HOT WATER HEATING at Gravesend Post Office and Telephone Exchange.

Drawings, Specification, a copy of the Conditions and Form of Contract, Bills of Quantities, Forms for Tender, etc., may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles Street, London, S.W.1, on payment of One Guinea. (Cheques payable to The Commissioners of H.M. Works, etc.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. J 233

HEATING.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive

Tenders before Eleven

a.m., on Tuesday, 23rd June, 1925, for LOW PRESSURE HOT WATER HEATING at Altenburg Gardens Telephone Exchange, Battersea.

Drawings, Specification, a copy of the Conditions and Form of Contract, Bills of Quantities, Forms for Tender, etc., may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles Street, London, S.W.1, on payment of One Guinea. (Cheques payable to the Commissioners of H.M. Works, etc.). The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. J 234

PORTABLE PETROL-DRIVEN CONCRETE MIXER.

THE DUBLIN PORT AND DOCKS BOARD is prepared to receive

Tenders for a Portable

PETROL-DRIVEN CONCRETE MIXER, adapted for street work, having a capacity of about ½ cubic yard, fitted with elevating loader.

Further particulars, if required, can be obtained from the Engineer, Port and Docks Board, East Wall.

Tenders to be received by the SECRETARY, Port and Docks Office, Westmoreland Street, not later than Eleven a.m., on Wednesday, 24th June, 1925.

The Board does not bind itself to accept the lowest or any Tender.

Port and Docks Office.
2nd June, 1925. J 219

Under a Deed of Assignment.
By Order of the Trustee, B. T. CREW, Esq
THE LUTON TOOL COMPANY,
DUNSTABLE ROAD, LUTON,
HENRY BUTCHER & CO.
have received instructions to offer

For Sale by Tender, as Going

CONCERN,
the Old-established
MACHINE TOOL MANUFACTURING BUSINESS
(Formerly Clark's Machine Tool Company),
Manufacturing a RANGE of CAPSTAN LATHES, S.S. and S.C. LATHES, SLOTTING MACHINES and WOODWORKING MACHINERY.

The assets include—
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GOODWILL.

The Factory and Land can be obtained on a favourable Lease, or the Freehold may be purchased from the Owners.

The Works may be inspected between the hours of Ten a.m. and Four p.m., from JUNE 16th to JUNE 19th, inclusive.

Tenders must be received before Twelve Noon, WEDNESDAY, JUNE 24th.

Tender Forms (when ready) may be obtained from :—

Messrs. CREW, TURNBULL & CO., Chartered Accountants, 4, Dove Court, Old Jewry, E.C.2, and George Street West, LUTON.

Messrs. HENRY BUTCHER & CO., Engineering Auctioneers, Valuers and Surveyors, 63 & 64, Chancery Lane, W.C.2. J 236

APPOINTMENTS OPEN.

India.—First-class Man

REQUIRED as Manager of Railway Wagon Department of important firm. Age 28 to 35 years. Modern shop and drawing office experience, and ability to control men. Five years' agreement with first class passage out and home. Write, giving full details of experience, and copies of testimonials, to "Z O. 721," c/o DEACONS Advertising Agency, 11, Fenchurch Avenue, London, E.C.3. J 229

CAPE TECHNICAL COLLEGE, CAPE TOWN.

Applications are Invited for

an ENGINEERING LECTURER. Graduate (or equivalent) in electrical engineering who has had a workshop training and subsequent experience in one or more of the branches of light-current engineering. The lecturer will be expected to conduct classes in telegraphy and telephony, wireless telegraphy and telephony and physics, and assist in the light-current section of the Department of Electrical Engineering.

Applications, in duplicate, must be submitted with certified copies of testimonials giving evidence of workshop experience, other experience technical qualifications and stating age of candidate before 23rd June, 1925. Salary £400-25-£500.

Conditions of service and other particulars may be had on application to :—

Messrs. CHALMERS, GUTHRIE & CO., LTD.,
9, Idol Lane,
London, E.C.3. J 223

EGYPTIAN STATE RAILWAYS, TELEGRAPHS AND TELEPHONES.

Applications for the following

APPOINTMENTS are REQUIRED and should be addressed to :—

THE GENERAL MANAGER,
c/o The Inspecting Engineer,
Egyptian Government,
Queen Anne's Chambers, Westminster,
S.W.1,

not later than June 10th, 1925.

1. ELECTRICAL SIGNAL ENGINEER, at £E. 600 per annum.
2. ELECTRICAL ENGINEER, at £E. 360 per annum.
3. ONE DESIGNER, at £E. 600 per annum, to assist in the Technical Office of Mechanical Dept.
4. ONE MACHINE SHOP FOREMAN, at £E. 600 per annum.
5. ONE JUNIOR DESIGNER, at £E. 360 per annum, to work in the same office as No. 3.

No other remuneration will be paid in addition to the salaries mentioned above.

Appointment will be made on contract for period of two years.

Copy of Contract and list of qualifications required from applicant can be obtained from the Inspecting Engineer's Office. J 164

EGYPTIAN STATE RAILWAYS, TELEGRAPHS AND TELEPHONES.

Applications for the following

APPOINTMENTS are REQUIRED and should be addressed to :—

THE GENERAL MANAGER,
c/o The Inspecting Engineer (Egyptian Govt.),
Queen Anne's Chambers,
Westminster, S.W.,

not later than June 10th, 1925.

1. ASSISTANT TO CHIEF MECHANICAL ENGINEER, at £E. 1000 per annum, to be in charge of the Drawing Office.
2. DESIGNER at £E. 600 per annum, to assist the candidate referred to above in (1).
3. TWO BOILER INSPECTORS, at a salary of £E. 480 each.

No other remuneration will be paid in addition to the salaries mentioned above.

Appointment will be made on contract for period of two years.

Copy of Contract and list of qualifications required from applicant can be obtained from the Inspecting Engineer's Office. J 101

Boiler Inspector.—An

EXPERIENCED MARINE ENGINEER, holding Chief's certificate, is REQUIRED by a large Company for service in the East. Applicants should have had at least two years' experience with one of the Boiler Insurance Companies and be qualified to carry out periodical and annual inspections of Lancashire, Spearing Vickers Water Tube, Yarrow Water Tube, Vertical Cross Tube, Cochrane and Loco. Type Boilers. Must be thoroughly conversant with the B.O.T. Rules governing Boiler design and capable of designing repairs. Age 32-35. Three years' agreement. Commencing salary equivalent £640 per annum upwards. Free quarters, but without messing, and free passage out and home.—Write, giving full particulars to BOX F., c/o The REGENT ADVERTISING SERVICE LTD., 165, Moorgate, London, E.C.2. J 189

Civil Engineer Required

by the GOLD COAST GOVERNMENT for the Kumasi Public Health Board, for a tour of not less than 12, nor more than 18 months' continuous residential service. Salary, £480 for the first three years of service, then £510, rising by annual increments of £30 to £720, and thence rising by annual increments of £40 to £920. Outfit allowance £60 on first appointment. Motor cycle allowance £48 a year, payable whilst on duty. Free passages and quarters, and liberal leave on full salary. Candidates, aged 25-35, must have received a good technical education and training in the office of a Municipal Borough or City Engineer, have had practical experience in surveying drainage, town planning, building construction, quantities and estimates. Must be able to ride a motor cycle.—Apply at once, by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W.1, quoting M/13565. J 216

Civil Engineers (Two)

REQUIRED by the GOVERNMENT of the GOLD COAST for the RAILWAY DEPARTMENT. Salary, £480 for the first three years of service, then £510, rising by annual increments of £30 to £720, and thence rising by annual increments of £40 to £920, with a seniority allowance of £72 per annum after passing the efficiency bar at £720 per annum. Outfit allowance of £60 on first appointment. Free passages and quarters, liberal leave on full salary. Candidates, aged 25-35, should have served pupilage with a Railway Engineer, or firm of engineers or engineering contractors engaged on railway construction. Must be good draughtsmen and competent in the use of theodolite level, etc., and have had at least five years practical experience on Railway and Engineering works.—Apply at once, by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting M/13644. J 217

ENGINEERING AT THE SCIENCE MUSEUM.

By Engineer-Captain EDGAR C. SMITH, O.B.E., R.N.

ONE of the post-war tasks of the staff of the Science Museum, rendered necessary by the lapse of time and the numerous additions to the exhibits, was the revision and re-publication of the catalogues of the mechanical engineering, naval and science collections. This work is now well advanced. Some ten or a dozen new catalogues have already been issued and others are in the press. Published under the auspices of the Board of Education at prices varying from one to two shillings each, they are among the cheapest engineering literature in the world. Simply regarded, as books of reference, they are worth a place on every engineer's bookshelf. Among the latest to appear are the catalogues of steam warships, mechanical road vehicles and stationary engines. Catalogues of the locomotive and aeronautical collections are available, and that dealing with marine engines is nearly ready. The catalogue of steam warships has been compiled by Mr. G. L. Overton, that of mechanical road vehicles by Mr. E. A. Forward, and that of stationary engines by Mr. H. W. Dickinson. The stationary engines catalogue deals mainly with steam boilers and engines, but there are also sections devoted to wind and water motors and gas and oil engines. It has some 200 pages of letterpress, full descriptions of over 500 exhibits and also 35 illustrations of important and historic machines. A valuable feature of all the catalogues is the series of short historical notes they contain.

Most of the catalogues of the Science Museum treat of one or other branch of engineering, and engineering may be regarded as the backbone of the Museum. It was an engineer who took the initiative in obtaining some of its chief mechanical treasures, while it was another engineer who first popularised the Museum by showing the models in section and in motion. Then, too, with but one exception, its directors have been trained engineers. Though not so old as the Conservatoire des Arts et Metiers in Paris, the Science Museum is far richer in historic machines, and its galleries are eloquent of the prominent part Great Britain has taken in providing the world with machinery. Not only did this country supply the machinery, but it was also the great training school for mechanics and if some of the pupils have outstripped their master, it is largely due to their superior resources and freer conditions. But pessimistic reflections about the decadence of British ingenuity or skill are soon dispelled by a stroll through the Museum, for not only does one see there the epoch-making inventions of Newcomen and Watt, Arkwright and Crompton, of Hedley, Stephenson, Symington, Bramah, Trevithick and Maudslay, but alongside these will be found the work of Yarrow and Thornycroft, Armstrong and Siemens, Elder and Clerk and Parsons, while a perusal of the list of donors shows that it comprises many of the most famous firms in the industrial world of to-day.

With its unrivalled collections, it must be presumed the Science Museum and its progress is a matter of moment to every student of engineering, but all the same there are possibly few who are acquainted with its history. It is only one of many notable institutions at South Kensington, and the story of South Kensington is little short of a romance. A hundred years ago the district was an open space given over to market gardens across which, at times, folk went in parties for mutual protection. The Museums of Industrial Art, of Natural History, of Science and Engineering, the Imperial College of Science and Technology, the Royal Colleges of Art and Music, the Royal School of Art Needlework, the Imperial War Museum, and the Imperial Institute all stand on ground which seventy years since was entirely undeveloped. The modern history of the district begins with the Great Exhibition, held in Hyde Park in 1851, and in a sense, South Kensington may be regarded as a memorial to the Prince Consort, after whom the Albert Hall was named. When that exhibition—for which the building known as the Crystal Palace was construeted—came to an end, the authorities found themselves in possession of a surplus of 186,000*l.*, and largely through the Prince Consort, this money was left in the hands of Commissioners to be used in any way they considered most likely to promote a knowledge of art and science, and their application to productive industry. Left to their own judgment, and fortunately unfettered by Government Departments, the Commissioners purchased an estate of 87 acres between Kensington High Street and Cromwell Road. Of this estate, 18 acres have been given up to roads, 17 acres are occupied by residential houses and some 50 acres have been allotted for public buildings, the sites of which have been sold to the Government and other bodies at less than their market value. So well, indeed, have the Commissioners managed their affairs that a conservative estimate places the value of their contributions to public services at 1,500,000*l.*, while the Commissioners still possess an estate worth 500,000*l.*, and an income of 20,000*l.*, most of which goes in scholarships.

The first institution to find a home at South Kensington was the Government Science and Art Department, the predecessor of the Board of Education, which in 1857, was transferred there from its previous headquarters in Marlborough House. It was this step which led to the founding of the South Kensington Museum housed for a long time in what were known to an older generation, as the "Brompton Boilers"—iron sheds with arched roofs. From this original Museum has sprung both the Victoria and Albert Museum, which is devoted to such subjects as architecture, sculpture, woodwork, metalwork, textiles and ceramics, and the Science Museum, which illustrates the progress of physical science, engineering and technology. It is impossible to follow the history of the Science Museum in detail, but three events in its early history were of special significance. The first of these was the removal to South Kensington, in 1857, of Bennet Woodcroft's Patent Office Museum, which, in 1883, was incorporated with the Science Museum, The second was the opening of the Royal School of Naval Architecture and Marine Engineering, in 1864, which led to the birth of the present splendid naval collections, while the third was the holding of a Loan Exhibition of Scientific Apparatus at South Kensington, in 1876, an international effort resulting in a remarkable display of instruments, some of which passed permanently into the collections of the Science Museum. All three events had far-reaching effects on the growth of the Museum, but the greatest debt undoubted, is to Woodcroft. It was he who obtained for the nation the "Rocket" and "Puffing Billy" locomotives, Bramah's press, Symington's engine, the Watt collections, Arkwright's original machines, the models of the Great Eastern and her engines, and many other valuable exhibits.

By the latter part of the '80's the scope of the Science Museum may be said to have been definitely settled, and its future development indicated. Gen. E. R. Festing was then the director, and it was under him that William I. Last began his work. The holder of one of the early Whitworth scholarships, Last had several years' practical engineering to his credit and as keeper of the naval and engineering collections he found full play for his abilities and enthusiasm. His working models, gained for the museum a good deal of popularity, and it was only natural that, on General Festing's retirement in 1904, Last should be appointed his successor. The Science Museum, however, was still a part of the South Kensington Museum, and to some degree its claims were subordinated to the claims of art, and its collections were ever in a crowded state. Attention was frequently drawn to this, but the turn of the tide did not come till 1909, when the palatial building now known as the Victoria and Albert Museum was opened for housing the art collections, and the Science Museum attained new dignity by being made an independent institution. At this time, too, an advisory committee of eminent men of science and engineers, with Mr. (now Sir Francis) Ogilvie as secretary, was set up to consider its needs. The outcome of this action was the presentation to the Government of a report proposing the erection of an entirely new range of buildings with ample floor space and good lighting, stretching from Queen's Gate to Exhibition Road. The unfinished galleries to be seen facing Exhibition Road at the present time represent the first third of that scheme.

With the scale of the new plans no one could find fault. The total areas of the old southern and western galleries, and the Science Library, amounted to some 125,000 sq. ft.; the first portion of the new museum was to have some 200,000 sq. ft., while the whole would have about 500,000 sq. ft., equal to about 11 acres. An account of the projected museum was given by Sir Francis Ogilvie, who has succeeded Last as director, to the Royal Society of Arts in 1913. By that time work on the new building had been begun, but before the concrete of the walls and floors was dry the war broke out, and most of the galleries which were to have been available in 1915 are still in the hands of the plasterers, carpenters, and painters. Then, too, a year or two ago the western galleries had to be vacated for the Imperial War Museum, and just at the present time, in point of accommodation, the museum itself is not much better off than it was in the '80's. How this hinders the work of the museum can be easily imagined. Most of the collections actually on view are far too crowded, while nearly 50 per cent. of its treasures are stored in the basement.

For the purposes of administration the objects in the museum are divided into four main groups: (i) industrial engineering, including textile, agricultural, mining, metallurgical, and electrical machinery; (ii) mechanical engineering, including stationary engines, road and rail transport, lifting appliances, pumps, measurement, and construction; (iii) water and air transport, with sections devoted to sailing ships, steam ships, warships, boats, harbours, docks, lighthouses, and marine engines, airships, and aeroplanes; (iv) science collections, with group of exhibits illustrating astronomy, mathematics, surveying, acoustics, optics, meteorology, geophysics and chemistry. Though by no means complete, this mere enumeration of the main subjects illustrated in the museum will give an idea of the vast and important fields covered. Most of them are departments of knowledge and industry extending with great rapidity, and among them will be found nearly all our key industries.

But though wide be the range of the exhibits to be found in the museum, wider still is the range of the interests of those who visit it. While the majority of visitors are without technical training there is day by day a steady stream of business men, professional engineers and craftsmen, teachers and students from all parts of the world who not only come to inspect the collections generally, but who expect to find something of value to them in their daily work. Specific enquiries relate to every branch of science and engineering. Oil mining, steam turbines, Diesel engines, calculating machines, kinematographs, rotary pumps, acoustical apparatus, water tube boilers, wireless gear, motor-car engines, refrigerators, smoke abatement, uniflow engines, sanitary appliances, gravity escapements, magnetos, sounding machines, corrugated ships and cotton gins, are but a few things regarding which definite information has been asked for. A pioneer from the borders of Swaziland came recently to see how he could improve his waterwheel; a group of sea-going engineers wanted to inspect such things as Doxford engines, flexible couplings and nodal drives.

A collision on the Thames leading to a case in court led to an enquiry for gyroscopic compasses, while the objective of a power engineer was to inspect a coal pulverizing plant. Instances such as these could be multiplied many times, and it is to meet the needs of such enquiries that it is essential that the museum should keep abreast of the times and that it should receive the support of the manufacturer.

Generally speaking, any such institution as the Science Museum has three main functions to fulfil. It should be a store house for historic apparatus and machines; it should be a great educational establishment aiming at enlightening the public in scientific matters, and it should also be the national industrial show room where the technical man can make himself acquainted with modern progress. The Science Museum aims at doing all this.

It is extremely rich in historic engines and scientific inventions; in its galleries are found many excellent demonstrations of scientific phenomena; while current practice in engineering and technology is regarded as equally important with the practice of the past. To the pursuit of research and its application to practical affairs there is no limit, and it is this continual growth which makes it very desirable that the building programme of this new museum should be accelerated if the work in the future is not to be hampered as it has been in the past. Founded about 70 years ago, since the '80's of last century the Science Museum has been regarded as a most important educational institution, but it needs little imagination to see that whatever value it has been in the past, will be far exceeded by the services it can render in the future. It has indeed almost boundless possibilities, and, as our industries grow, so ought the Museum to grow. The support of the Museum is not so much a matter of sentiment as of sound business policy. Our debt to the workers of the past is undoubtedly great and is not likely to be forgotten. But science and engineering and shipping are the sources of our national strength, and if it be worth while spending money on temporary exhibitions such as were to be seen last year in the Palaces of Engineering and Industry at Wembley, it is still more worth while that our permanent exhibitions of such things should be well displayed and worthily housed.

THE LITTLETON RESERVOIR OF THE METROPOLITAN WATER BOARD.

(*Concluded from page* 631.)

THE two 8-ft. reinforced concrete conduits which convey the water from the Littleton reservoir are shown in course of construction in Figs. 47 and 48, herewith, and a drawing illustrating the method of connecting them to the outlet shaft will be found on page 481 of our 114th volume. They are continued on a curve for a distance of about 100 yards, passing under the Ashford Road, on the eastern side of which one is, at present, capped off. At this point, connections are made from both conduits to a gauging tank which supplies additional water to the Staines aqueduct, and one of the conduits, reduced to a diameter of 6 ft., follows the course of the aqueduct to supply the Board's works at Kempton. It is here reduced in diameter, and continued on to Hampton as a 48-in. cast-iron pipe, as will be clear from the map of the whole district, reproduced in Fig. 49, on page 691.

A section through the two 8-ft. conduits, the centres of which are 10 ft. apart, is given in Fig. 50 on page 691, this section being taken through manholes provided near the gauging tank, above referred to, in order to give access to the interiors. Four-inch connections to the manhole castings provide for the escape of air from the conduits, the pipe conveying the air into the open gauging tank. Figs. 51 and 52 show the distribution of concrete of the different grades employed, and Fig. 53 illustrates the arrangement of the reinforcement and its connection to the flange of the cast-iron manhole pipes. The circumferential reinforcement consists of plain rods $\frac{3}{4}$ in. in diameter, spaced $5\frac{1}{2}$ in. apart, while for the longitudinal reinforcement, $\frac{1}{4}$-in. twisted square bars, spaced 12 in. apart, are employed. Three $\frac{3}{4}$-in. longitudinal bars were, however, inserted at the top and bottom of the conduit to give greater strength, as shown in Fig. 50, and, where the conduits pass under the Ashford Road, additional circumferential reinforcement is provided, as indicated by the dotted lines in Fig. 54, page 692. The bars pass through cored holes in the flanges of the cast-iron connections and are secured by nuts and washers, as is most clearly shown in Fig. 56. The joints between the cast-iron and concrete were caulked with lead wool, space being left for the purpose by inserting folding wedges of wood before placing the concrete. Timber centring was used in the construction of these conduits, as can be seen in Fig. 48.

The connections from the conduits to the gauging tank are shown in Fig. 54, from which it will be seen that the connection is made by a branch piece 4 ft. in diameter internally, a 45-deg. bend, a straight piece connected to a 48-in. sluice valve, and a bell-mouthed outlet. In the case of the conduit nearest the gauging tank, the straight pipe is omitted, the 45-deg. bend being bolted directly on to the flange of the sluice valve, as shown in Fig. 59. The connection between the reinforced-concrete work and the cast-iron branch is similar in design to that of the manhole pipes referred to above, and the actual arrangement of the reinforcement is shown in Fig. 55.

As already stated, one of the 8-ft. conduits is capped off in the neighbourhood of the gauging tank, but its diameter is first reduced to 6 ft., since it will eventually be continued at that size. Fig. 57 shows the manner in which the diameter has been reduced over a length of 10 ft., and it will be noticed that the invert is kept horizontal while the top and sides are tapered down to the smaller diameter. A short cast-iron flanged pipe has been inserted at the end and secured to the longitudinal reinforcing bars, as shown. To this flanged pipe, another, 6 ft. in length and tapering from 6 ft. to 4 ft. in diameter, is bolted, the smaller end being closed by a dished and ribbed cap, shown separately in Fig. 58. This tapered pipe was provided in order to reduce the total pressure on the capped end, and it will be removed when the conduit is extended.

Details of the gauging tank are illustrated in Figs. 60 to 65 on page 692, from which it will be seen that the connections from the conduits open out into two rectangular concrete shafts in which the water rises, flowing out through rectangular openings into the gauging tank proper, which lies parallel with the conduits. This tank, which is constructed of concrete and is 22 ft. in width, is provided with four

LITTLETON RESERVOIR; OUTLET CONDUITS.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER.

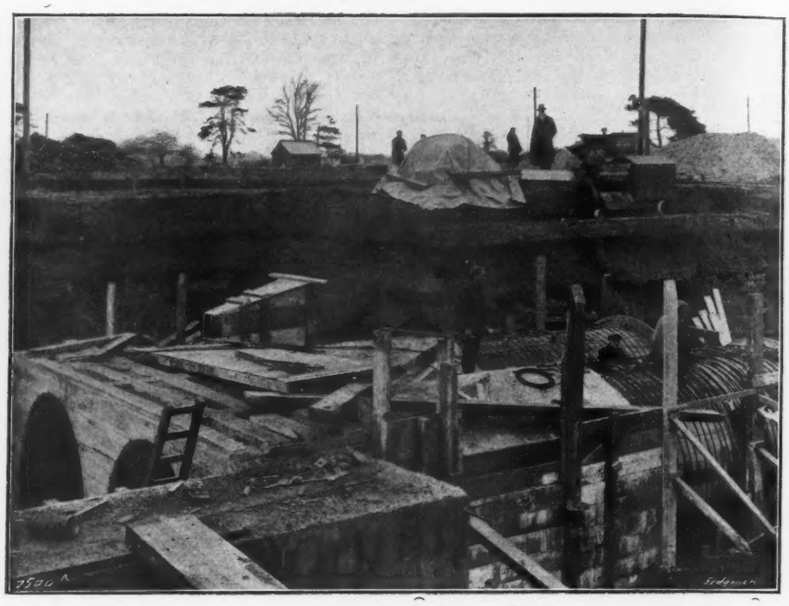


FIG. 47. CONNECTION OF 8-FT. REINFORCED-CONCRETE CONDUITS TO OUTLET SHAFT.

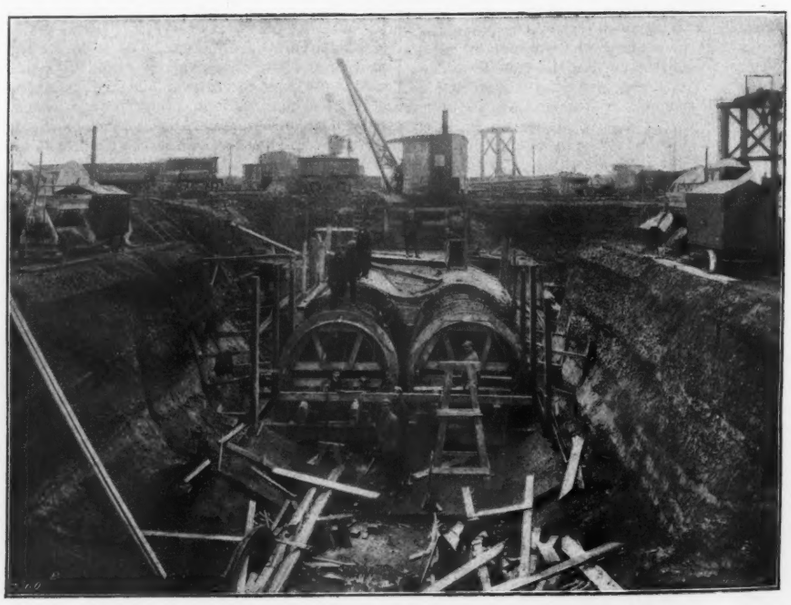


FIG. 48. 8-FT. REINFORCED-CONCRETE CONDUITS UNDER CONSTRUCTION.

LITTLETON RESERVOIR; OUTLET CONDUITS.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

Fig. 49.

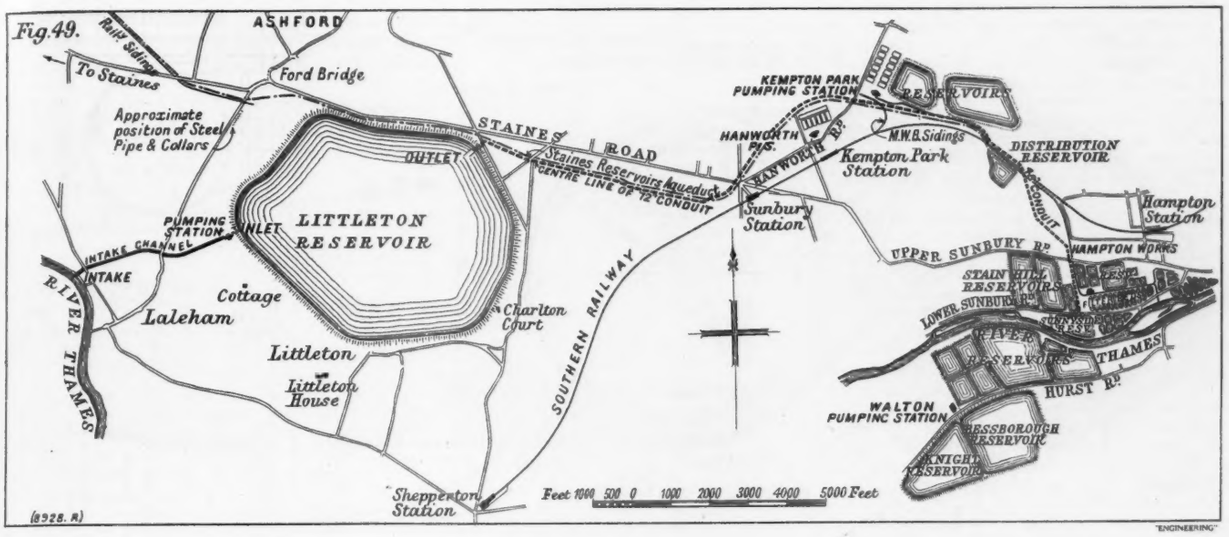


Fig. 50.

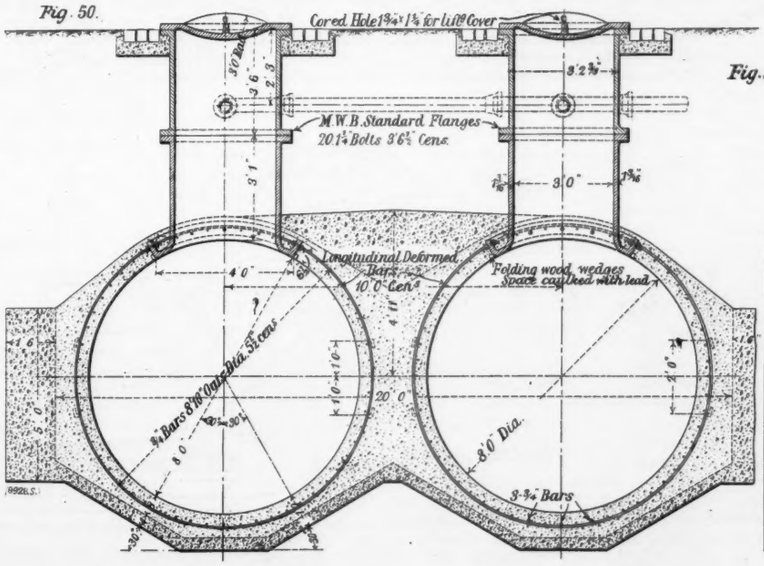

Cored Hole 1¾" Ø for 1½" Ø Cover
M.W.B. Standard Flanges
20 1¼" Bolts 3'6" Cens.
Longitudinal Deformed Bars 10'0" Cen.
Folding wood wedges Space caulked with lead
¾" Bars 8'0" Cents. Dia. 32 Cens.
8'0" Dia.
3-¾" Bars
(8928.S.)

Fig. 51.

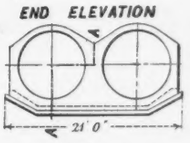
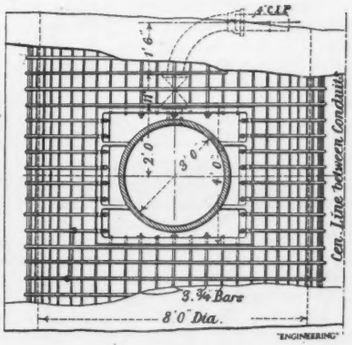


Fig. 52.

Fig. 53.



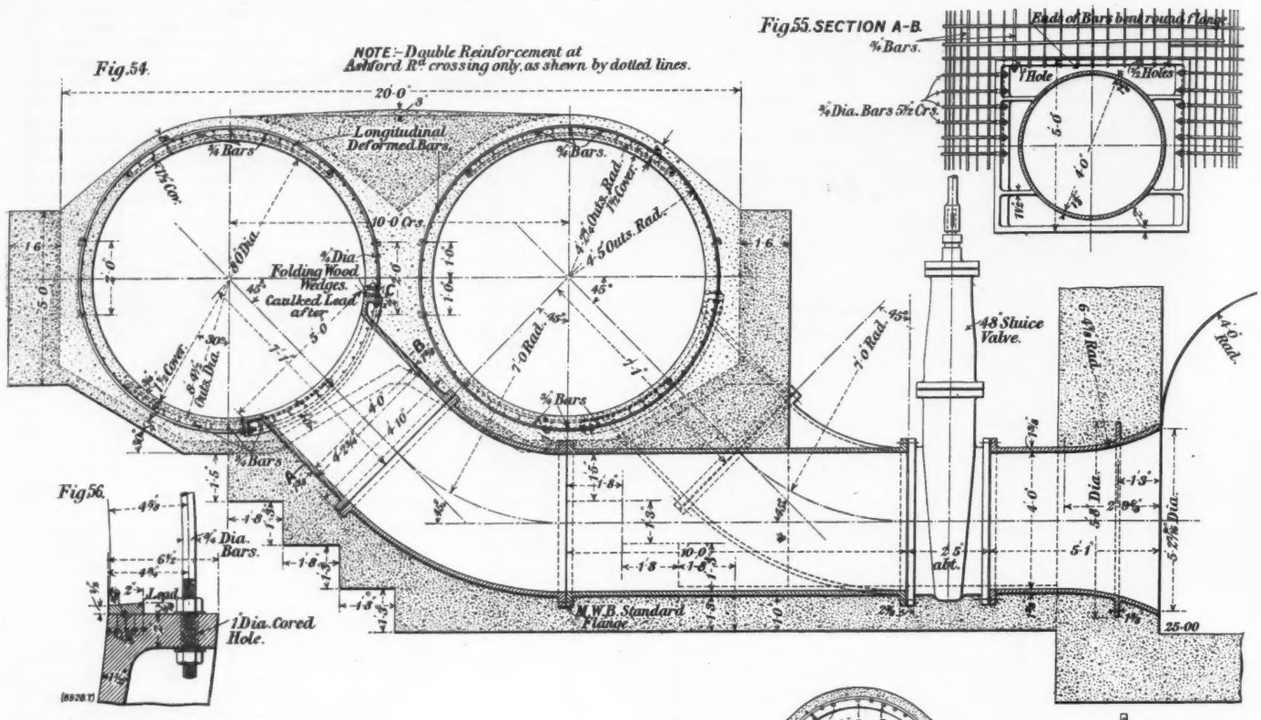
baffle walls of reinforced concrete, details of the reinforcement of one of these being given in Figs. 63 and 64. The water flows over the top of the first baffle, through an opening under the next and so on, being deflected by a low weir formed on the floor of the last compartment and passing out through a rectangular measuring orifice, the object of the weir being to direct the flow upwards, thus checking a direct passage through the orifice. The measuring orifice consists of a gun-metal plate formed with a sharp-edged rectangular opening 13 ft. in width and 2 ft. in depth, the plate being secured by countersunk gun-metal screws to a cast-iron plate fixed to the concrete end wall by means of Lewis bolts. The orifice, of course, works completely drowned, and this method of measurement has been adopted, in preference to an open weir, in order to reduce the loss of head to the minimum. Connections from the up-stream and down-stream sides of the orifice are taken by 4-in. cast-iron pipes with spigot and socket joints, to a gauge house located as shown in Figs. 60 and 65, the gauge house containing the necessary instruments for recording the flow, which will reach a maximum of about 50,000,000 gallons a day; the recording apparatus is being supplied by the Palatine Engineering Company, Limited. The water from the gauging tank flows through a rectangular channel 15 ft. wide, 9 ft. deep and about 18 yards in length, which is directly connected to the Staines aqueduct.

The other conduit, reduced to 6 ft. in diameter in a similar manner to the one which has been temporarily capped off, is continued for a distance of some 3,800 yards to the Kempton pumping station, following the course of the Staines aqueduct and running on the southern side nearly as far as Sunbury Cross, where it is taken under the aqueduct and continued on the northern side, as shown in the map, Fig. 49. The inclination is 0·6 in 1,000, and the capacity of the conduit, which, of course, varies with the available head in the reservoir, is of the order of 45,000,000 gallons a day. The reinforcement for the 6-ft. conduit is generally similar to that used in the 8-ft. conduits, but part of the former is being constructed with the aid of collapsible steel-plate centring supplied by Messrs. Christmas and Walters, Caxton House, S.W.1. The centring, which is illustrated in Figs. 67 and 69, on page 704, was made in 5-ft. lengths, 34 of which are in use, the cylinder being formed in four segments, with longitudinal joints at the top and bottom and on each side; similarly jointed channel rings were provided at each end. The cylinder is suspended in position from the top of the trench, the four segments being held in position by a horizontal strut of timber and by vertical steel rods fitted with turnbuckles, and the concrete forming the invert is placed and tamped through movable doors provided in the lower portion. After the remainder of the concrete has been placed from the top and allowed to set, the struts are removed and a steel-framed carriage run in on rails formed of bulb angles. Screwed struts at each end of this carriage are connected to the cylindrical form at the ends of the top and bottom longitudinal joints, and, by operating hand wheels so as to shorten the struts, the upper segments are lowered and the lower segments raised into the positions shown in Fig. 67, so that they can be moved forward and set up for the next section of the work.

An interesting feature in connection with the construction of the 6-ft. conduit is the method of reducing the possibility of leakage through any of the circumferential joints caused by stopping and re-starting the work of laying the concrete.

LITTLETON RESERVOIR; OUTLET CONDUITS.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.



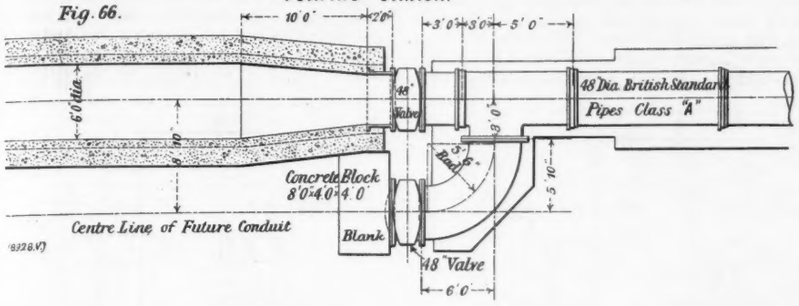
At all such places, circumferential strips of lead 12 in. in width and attached to 2 in. by ¼ in. steel rings by means of gutter bolts with lead washers, are inserted across the joint, the steel ring taking the place of one of the ordinary reinforcing rings. The lead strips can be seen in position in Fig. 68, which shows the trench with the reinforcement in position before concreting. In general, the placing of the concrete was continued until one of the lead strips was reached, but if for any reason the work had to be stopped at any other point, an additional lead strip was inserted at that point. It will be obvious that, with this device, the leakage which might result from the failure of the fresh concrete to adhere perfectly to that previously laid would be reduced to a negligible quantity owing to the increase in the length of the leakage path caused by the interposition of the lead strip.

From the 6-ft. conduit, a 36-in. branch has been provided for the supply to the Hanworth filters, and two 48-in. connections have been made for the direct supply of the primary filters which are to be constructed at Kempton. Two other 48-in. branches have been provided just east of the Kempton pumping station for the supply of the primary filters by means of the existing pumping plant, which will be used when the head of water in the Littleton reservoir is not sufficient to raise the water up to the level of these filters. At the Kempton pumping station, the 6-ft. conduit is reduced to 4 ft. in diameter, and continued in the form of a 48-in. cast-iron main for the supply of about 20,000,000 gallons a day to the filter beds at Hampton. The connection between the 6-ft. conduit and the 48-in. main at Kempton is shown in Fig. 66, and it will be seen that a branch is provided there so that a connection can be made to the second 6-ft. conduit when this is laid in the future. Fig. 70, on page 704, shows the reinforcement and timber mould for the tapered end of the 6 ft. conduit, where the latter is connected to the 48 in. cast-iron main, and also shows, on the left, the 48 in. connection to the pump suctions. Fig. 69 has been reproduced from a photograph taken at the same point, but looking in the opposite direction and showing the steel forms in position for completing the end of the 6 ft. conduit. The 48-in. main has a total length of 2,880 yards, of which 815 yards were laid in heading and the remainder in open trench. The average depth of the main below the surface, where in heading, is about 25 ft. and the maximum depth 50 ft. As a protection for the main, the whole of the heading was completely filled up with concrete after the main had been placed in position, and, for the same reason, the bottom of the trench, where in open cut, was filled with concrete on each side up to the level of the top of the main when the depth exceeded 15 ft. A Venturi type meter has been installed at Hampton for gauging the supply to these beds and similar meters will be fitted on all other branches, so that an account can be kept of the manner in which the whole of the water from the reservoir is utilised.

In concluding our account of this very interesting and important piece of work, we wish to acknowledge our indebtedness to Mr. Henry E. Stilgoe, M.Inst.C.E., the Chief Engineer of the Metropolitan Water Board, for permitting its publication and for supplying us with the drawings and photographs from which our illustrations have been reproduced.

JUNCTION OF 6FT. DIA. CONDUIT WITH 48 INCH DIA. CONDUIT, NEAR KEMPTON PUMPING STATION.

Fig. 66.



THE THEORY OF MAGNETISM.

THE "Recent Developments in the Theory of Magnetism," on which Professor Charles G. Darwin, F.R.S., of Edinburgh, discoursed at the Royal Institution, on May 15, suggests novel points of view rather than an explanation of the obscure character of magnetism. All substances are probably magnetic, though to enormously varying degrees; but why two or three kinds of magnetism? A bar of iron or nickel placed in a magnetic pole gap develops a north pole opposite the south pole of the magnet, and *vice versa;* these metals are called ferromagnetic. Aluminium and some other metals called paramagnetic have the same property, but their magnetism is 100 million times weaker. Most elements, notably bismuth and antimony, as also copper, gases, &c., are diamagnetic; a bar of copper placed in the pole gap develops a feeble north pole opposite the north pole. So far, we have assumed the magnetic field to be uniform, with parallel lines of force. When the field is not uniform, the lines being curved between two points, or converging between a square pole and a knife edge or cone, the paramagnetic body suspended in the pole gap, tends to move into the region of stronger magnetic force, and the diamagnetic body to move out of that region; the former places itself in the line of the poles, the latter equatorially. The magnetic susceptibility of paramagnetic bodies is positive, that of the diamagnetic bodies negative. Electric currents also have magnetic effects; it is, therefore, concluded either that the electric current is really a magnet, or that a magnet is a current—the latter, Professor Darwin said, was certainly the correct alternative.

The current flowing through a wire surrounding a cylinder would magnetise the cylinder along its axis. At the moment of making the current, an eddy current of opposite direction would be induced in the cylinder, which current, if not stopped by resistance (as it would be at any but very low temperatures), would persist and weaken the field. That was the case of the diamagnetic atom. In the paramagnetic atoms a second property came in; each atom had a magnetic moment, even in the absence of a field. In the presence of a field, the little atomic bar magnets would swing to and fro, but point more frequently down the field than up the field; that would give an extra magnetic moment down the field and would be paramagnetism. Unfortunately, this explanation was too simple. The moment was caused by revolving electrons which behaved like a spinning top, always moving at right angles to the direction in which it was pulled; the atom would thus not point along the field, but precess round it, and there would not be any gain of moment in the direction of the field, were it not for collisions between the atoms. These collisions would enable the axes of the tops to change and, in fact, to point more frequently towards than away from the field, and that effect might outweigh the always present diamagnetism. That collisions were concerned was shown by the fact that paramagnetism—not diamagnetism—was influenced by temperature; in a cold gas the gentle collisions allowed the atoms to settle down along the field, in a hot gas the collisions made nearly as many atoms to point away as towards the field. The averaging of the moment of the atom on dynamic principles was a matter of great difficulty, and writers had, therefore, tried to make short cuts, with various results: some claimed to have proved that there would be no paramagnetism, others denied diamagnetism, some both. The essential point was that the atom had the properties of a spinning top.

For this reason the attempts of O. Stern and W. Gerlach to determine the magnetic moment directly constituted one of the most remarkable lines of experiment of this century. Professor Darwin criticised the arbitrary indirect magneton determinations of others without mentioning any names. Stern and Gerlach boiled metals, silver in the first instance, in a small electric furnace, and passed the gaseous atoms in high vacua through two vertical slits in series on to a cooled glass plate—cooled in liquid air sometimes—to which they adhered; after four hours nothing was visible until the streak—actually, only 1 mm. in length and 0·05 mm. broad, to get uniform conditions—was "developed" as in photography. Before reaching the glass plate, the "atomic rays" passed through a powerful field between a slotted square pole and a knife edge. The atoms of silver having a magnetic moment, should be deflected from the straight path when the field was excited, and on the classical theory the streak should have been spread into a lens-shaped spot, if the atoms deposited had arbitrarily pointed in all directions. A lens was observed; but it was drawn out into a peak on the side facing the knife pole, and there was no silver deposit in the centre (where the particles should have concentrated on the old theory), the lens consisting of two arcs. That indicated that all the atoms were oriented parallel to the field, towards it or away from it.

This result would have been astonishing 20 years ago, but had indeed been anticipated on the quantum theory. According to this theory the atom should have a definite magnetic moment, a multiple or submultiple of the "Bohr magneton"—a name chosen in distinction from the old magneton. Now the atoms of silver, gold and copper were actually found to have each a moment of one Bohr magneton; thallium gave a moment of ½ magneton; tin, and particularly bismuth, yielded doubtful results; lead gave no effect, in which it accorded with iron which behaved here like an unmagnetic metal, a paradoxical result. It was very difficult to explain how the atom could point away from the field. As it evaporated it might have any direction; when it entered the field it could only be made to point away by gaining energy, and there was nowhere from which to gain it. But dynamical toleration had grown recently and the probability was now recognised, that energy is conserved only on the average, not exactly.

The older calculations of para- and diamagnetism had essentially depended upon the assumption of arbitrary atomic orientation. Gerlach's above-mentioned experiments had shown that this could not be true in his case, and then A. Glaser demonstrated that it was not true for gases either. The magnetic susceptibility of gases was exceedingly small, unless they were compressed; but Glaser had, nevertheless, been able to experiment in good vacua. He used a modified Curie balance, which really embodied the differential method first used possibly by Archimedes in his experiments on the buoyancy of bodies in air and water. He suspended a glass rod (rendered slightly paramagnetic by very cautiously fusing different glasses together) in the gas. In the vacuum the field (of 5,000 gauss, 12,000 gauss in Gerlach's experiments) twisted the rod round by a definite amount; in a paramagnetic gas the twist should be smaller, because the glass would float by buoyancy; in a diamagnetic gas the twist should be greater. The graphs obtained in experiments, in which the gas pressure was lowered from 900 mm. to 0,

consisted of three parts, a straight line portion directed to the origin, a curved portion, and again a straight line portion pointing to the origin, but this time at a different slope. The densities at which the curves changed were different for the different gases tried. In hydrogen the first change occurred at 600 mm., in nitrogen at 400 mm., in carbon dioxide at 300 mm.; the second change set in at very low pressures in all the three cases. Exact constancy of temperature and field intensity was imperative in these experiments.

The curves indicated that the magnetic susceptibility of the gases increased, in each case, to three times the original amount as the density decreased. The analogy between the Gerlach and Glaser experiments was only superficial. If the collisions between the gas atoms (or rather molecules) were responsible for the difficulty the atoms experienced in arranging themselves in alignment and the decreased susceptibility with increased density, one might, Professor Darwin remarked, on certain assumptions expect an effect of two-thirds (not one-third) the decrease in the susceptibility. He referred in this connection indirectly to his calculations respecting flat-disc atoms (not spherical) made with respect to Rutherford's experiments on collisions between atoms and α particles. But the difficulty involved in the whole principle of diamagnetism was the conservation of the spin of the tops during collisions. Further experiments were intended by Glaser, especially at low temperatures and with the strongly paramagnetic oxygen and the monatomic rare gases. So far these experiments on the magnetic susceptibility of gases did not seem to fit in with the general scheme, and they might lead to surprising new developments in physical theory.

When Professor Willy Wien, of Munich, in whose laboratory Gerlach and Glaser made most of these experiments, had reviewed these researches last month in three lectures given at King's College, London, more from the standpoint of the quantum theory than experimentally, he had concluded that the quantum theory did not dispose of all the difficulties. He had also expressed regret that iron had not chosen to prove itself magnetic in their researches.

THE ELECTRIFICATION OF THE IRISH FREE STATE.

(*Continued from page* 663.)

AN interesting and important part of the scheme is the transmission network and the devices by which the generating, control and supply plant and system are to be protected against breakdown and accident. The highest tension lines, carrying at 110,000 volts and delivering at from that to 100,000 volts, lead to transformer stations at Dublin and Cork, and in the full development also at Maryborough, at each of which the voltage is transformed from 110,000 to 38,500, and serves to feed what is termed the 35,000 volt network. The Maryborough station is to have two units each of 10,000 kv.-a.; in the partial development Dublin will have three units each of 15,000 kv.-a. and Cork two units each of 10,000 kv.-a., with an extra unit each of the same size on full development. At numerous points, listed in detail in a series of schedules, 35 and 10 kv. volt lines are led to transformers in houses or on poles, where the voltage is stepped down to 10,000 or 380 volts according to the anticipated circumstances of local demand. The generators are furnished with a system of maximum time relays, direction relays and other devices for disconnecting any one of them that is threatened with injury through internal fault or an excessive voltage rise. The protection of the 35-38·5 kv. and the 100-110 kv. lines is a more complex problem, and the report gives particulars of the manner in which these lines are to be so safeguarded as to cut out from the network any part or section of the system in which a fault occurs without affecting the working of the rest of the system.

Fig. 7 shows a general plan of the selective protection arranged in the full development for the 35 and 110 kv. lines throughout the entire area of supply. The principle of the arrangement used for the 35 kv. system is shown in Fig. 5, and essential details of it in Fig. 6. It is based on the fact that current flows to, and not from, a point at which a fault has developed, that each switch can be provided with a power direction-relay, which locks its tripping gear when current flows to the generator and allows its release when current flows in the other direction, and that it will be released on occasion of a fault, but not otherwise, if it lies on a ring of sub-stations connected radially with a central feeding station, and is controlled by a time relay so dimensioned in respect to the other similar relays that the time limits of incoming feeder switches lying along the ring in one direction from the feeding station increase progressively, while those of the outgoing feeder switches decrease similarly. It will be seen, moreover, that if the time setting of the switch is more than half the product of the time difference between the settings of successive switches and the total number of stations, including the central station (or one less than that number, should it be odd), a power direction relay will not be required. In Fig. 5 arrows show the direction in which the current relays of the switches a to h are set for release, with the time in seconds for which they are supposed to be set; in this example a fault in line k_1 would allow switch d to trip after two seconds and switch c after three seconds in all, while with a fault in k_2 switch b would trip after one second and a after four seconds in all. The number of stations being four and the progressive time difference one second, only those switches will require power direction relays of which the times do not exceed two seconds. The application of this arrangement to the 35 kv. network is indicated in Fig. 7. The stations on the system are

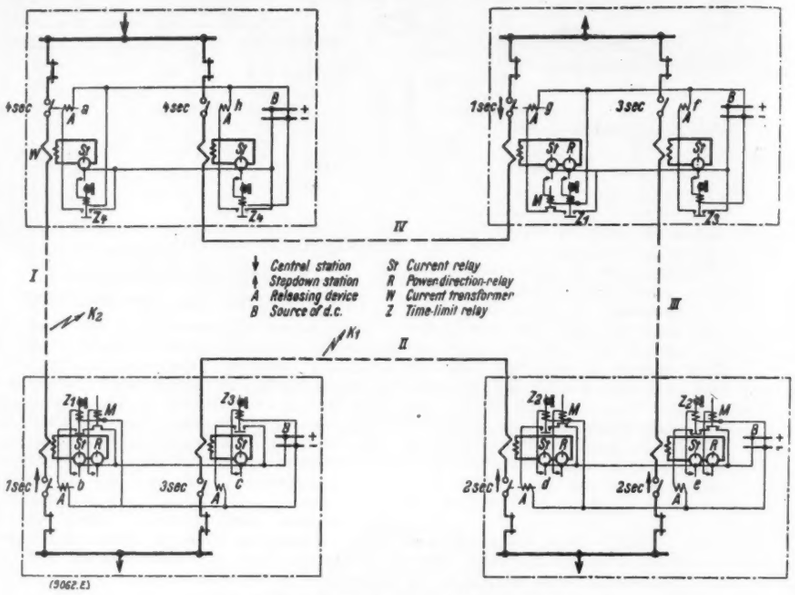


Fig. 5. Diagram of the Selective Protection.

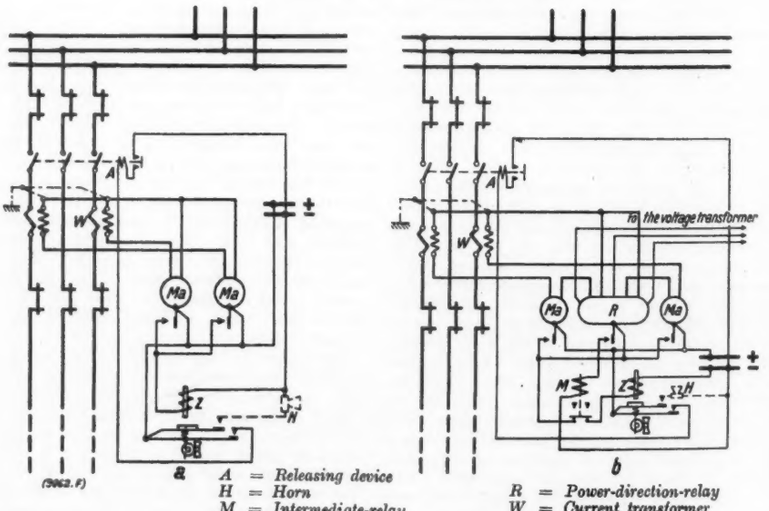


Fig. 6 Details of the Selective Protection.

the power station and the Cork, Maryborough and Dublin transformer stations. The figures next to the switches are the time settings; where an arrow is also shown, the switch is released only on occasion of overloads going in the indicated direction. In the switches a to f the time setting is 0; this means that these switches, which command the intermeshing, are immediately disconnected as soon as they carry an overload, an arrangement that avoids complicating the protective equipment needlessly.

The 100 kw. current between Limerick and Dublin is carried by two parallel overhead lines by way of Maryborough (Fig. 7), which are protected by so balancing the currents in the two lines that

the sound line is kept alive by a direction relay, and it is protected by overload relays immediately the direction relay comes into operation. The details of this "figure of eight" system are shown in Fig. 8. From Limerick to Cork only a single line runs, and is protected by simple overload time relays, with a longer time setting at Limerick than at Cork.

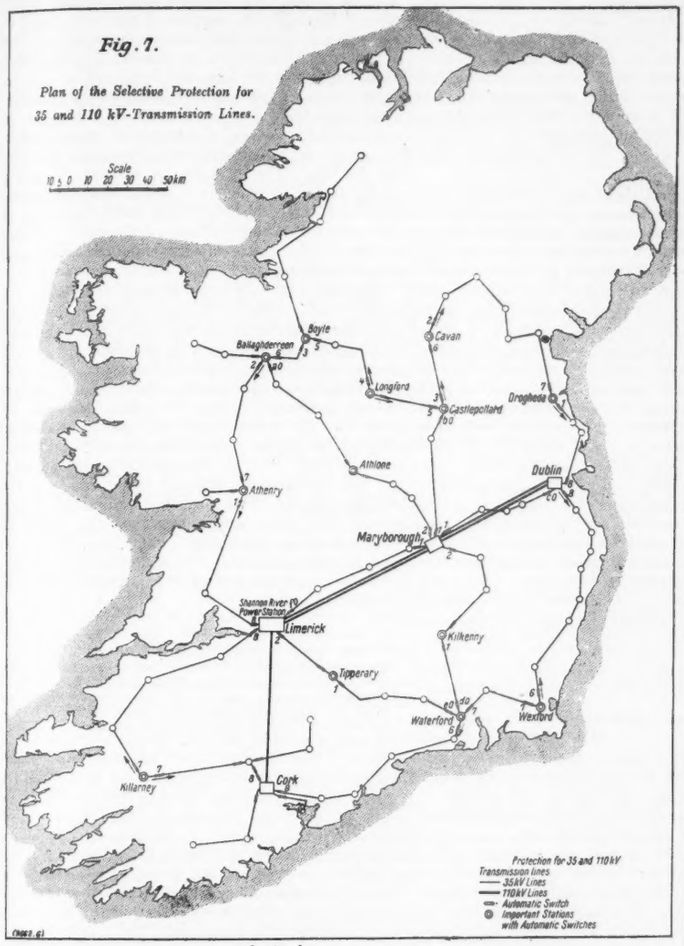
A construction adopted to minimise the mischief of earth faults is the Bauch extinguishing transformer, the operation of which may be followed by reference to Figs. 9 to 12. An earth fault causes the line voltage to drop to zero, and the voltages in the two other lines to increase $\sqrt{3}$ times and displace their phase from 120 deg. to 60 deg., as illustrated in Fig. 9. This not only strains the insulation of the intact lines but may lead to the formation of an arc, across which a capacity earth current, of a magnitude depending on the length and voltage of the network, may flow to earth, and both through the current and the arc serious damage may be done. An earth fault of a very dangerous type may also be produced by the reduction of the insulation resistance—as, for instance, by hair cracks in insulators—to an extent that leads to a breakdown but absorbs all, or nearly all, the service voltage in doing so. In arcing to earth travelling waves are released throughout the network, but on the failure of the voltage the arc ceases, striking again as the voltage recovers. In a 50-cycle current the arc will thus strike earth and release waves throughout the system at least 100 times a second, thus endangering the apparatus, especially when the network contains transformer windings. The Bauch transformer operates by sending an induction current of magnitude equal to that of the capacity earth current but displaced by 180 deg., thus preventing any current from flowing across the fault. The path of the current with and without this arrangement is indicated in Figs. 10 and 11. In actual construction the result is obtained by connecting the secondary winding of the transformer in delta through an adjustable choking coil, as indicated in Fig. 12. In the absence of an earth fault on the line the choking coil carries no voltage. Should an earth occur, producing increase of current and phase displacement in two lines, the choking coil loads the secondary winding of the transformer inductively with a current that passes to the primary and flows to earth along its earth connection. By giving suitable dimensions to the choking coil and providing regulating steps this inductive extinguishing current can be so regulated as always to have about the same magnitude as the earth currents.

Against excess voltage the 100 kv. lines are protected by protective switches between transformers and lines, the use of the extinguishing transformers last described, and separate high value choking coils in series with the transformers. Similar provisions are made for the 35 kv. network, and in addition horn-arresters with oil damping resistances are supplied, fitted with automatic oil-immersed switches in series with the horns, which cut in additional resistance after the primary resistance has destroyed the arc, and thus prevent the formation of a fresh arc. The connections necessary for this result will be followed on Fig. 13. It will be observed that the horn arresters for equalisation to earth and between the phases are grouped into fives.

(To be continued.)

Fig. 7.

Plan of the Selective Protection for 35 and 110 kV-Transmission Lines.



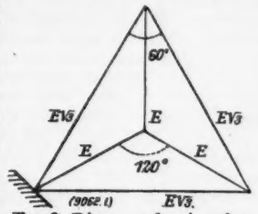


Fig. 9. Diagram showing the phase displacement.

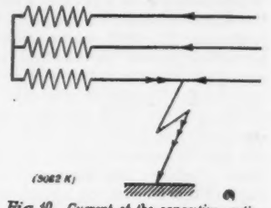


Fig. 10. Current of the capacitive earth leakage carried from a transmission line.

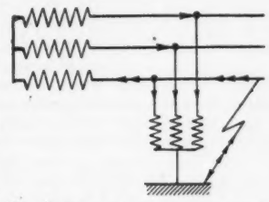


Fig. 11. Current of the inductive extinguishing transformer carried in case of earth leakage from the transmission line.

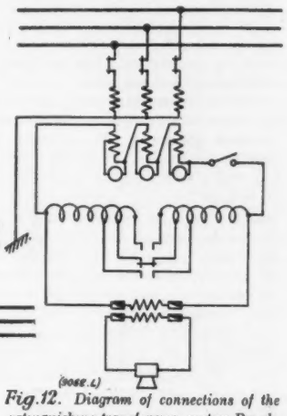


Fig. 12. Diagram of connections of the extinguishing transformer, system Bauch.

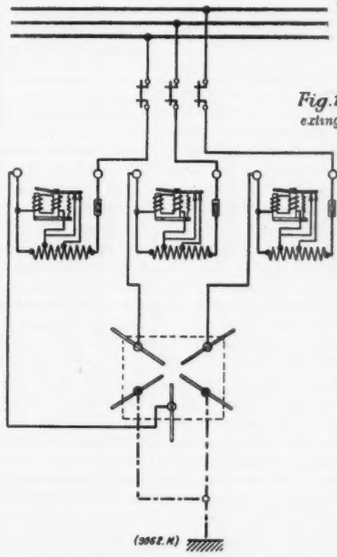


Fig. 13. Star-delta Protection.

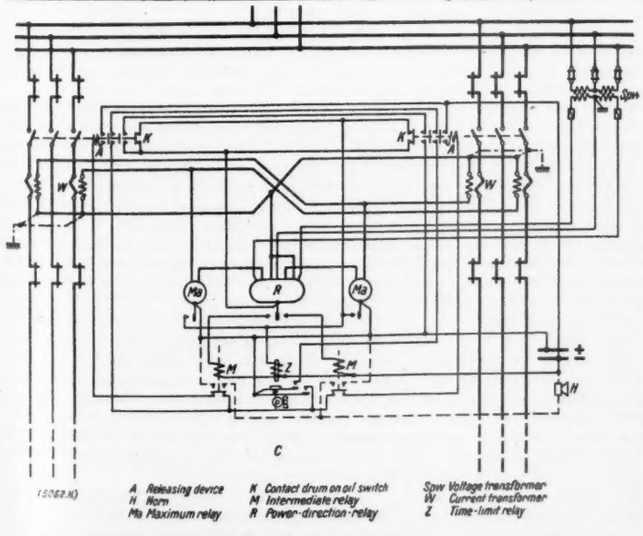


Fig. 8 Balanced System for two Parallel Lines (so called "Figure of Eight Protection").

LITERATURE.

Cotton-Cellulose. Its Chemistry and Technology. By A. J. HALL, B.Sc., F.I.C. London: Ernest Benn, Limited. Price 30*s.* net.

WHEN noticing an American translation of Heuser's "Cellulose Chemistry," on page 390 of our issue of September 12, 1924, we remarked that there were numerous papers on cellulose and books dealing with phases of the industry, but that a comprehensive English treatise on the subject did not appear to exist. That want has since been met in a very satisfactory manner. Mr. Hall's "*Cotton-Cellulose*" is a book of unusual merit. As chief chemist to the Silver Springs Bleaching and Dyeing Company in close touch with the actual industrial problems, he was able to secure the assistance of textile firms of world's repute, of the British Cotton Industry and Linen Industry Research Associations, and of chemists distinguished in this domain. The associations have recently added a great deal to our knowledge of textile technology, and Mr. Hall certainly understands how to make a scientific book informative and readable.

Cotton represents the purest type of cellulose produced in nature, of which it contains 90 per cent. in some instances. Whether or not the different colloidal celluloses isolated from different plants are really identical, as some believe, seems likely to remain an open question. It is generally conceded that the cellulose molecule is a complex of the formula $(C_6H_{10}O_5)_n$, where the unknown n may vary. But, Mr. Hall points out, the properties of cellulose may be modified considerably during its extraction, and so celluloses of different origins may continue to differ chemically. Physically they are sufficiently different, as is shown in the first instance by the staple, *i.e.*, the length of the cotton hair. In Sea Island and Egyptian Upland cottons the staple may reach 1¾ in. or 1¼ in,; in ordinary American cotton and in most Indian cottons it is smaller. These figures are important in the trade, since America supplies 60 per cent. of the world's cotton, India 18 per cent., and Egypt 6 per cent. There are about 8,000 hairs in a boll of cotton, of greatly differing length; all the hair is twisted with frequent reversals of the convolutions; wetting and stretching alter the convolutions, but the hairs subsequently reassume their original condition. Mr. Hall devotes his first chapter—regrettably but unavoidably short—to these physical properties.

The chemical changes of cotton are more permanent and more intense than had been assumed. In addition to the 90 per cent. of cellulose, the cotton contains moisture (about 8 per cent.), nitrogen (possibly as a protein), and fat, wax, resin, phosphorus in small proportions, often characteristic of origin and maturity. Since dyers and manufacturers of paper and yarn, artificial silk and explosives all require pure cellulose, those constituents are removed by what is technically known as bleaching in keirs, an alkali boil to remove the fats, &c., followed by a hypochlorite treatment to destroy the grey colouring matter, and subsequently by some acid treatment. Purification by organic solvents, with recovery of the solvents and wax, has not yet been a commercial success, and direct "chemicking" with chlorine, hydrogen peroxide and acids may degrade the cellulose, as even dilute alkali does in the presence of oxygen or air. That cotton steeped in caustic soda would swell and shrink and acquire an increased adsorptive power for dyes was discovered by John Mercer in 1844; Lowe further observed in 1889 the increase in lustre obtained when the mercerised cotton was kept stretched while being washed. At present more cotton is mercerised for increasing the lustre than for improving the dyeing capacity. In caustic potash the cotton swells only half as much in diameter as in soda. The chemical nature of mercerisation is still unsettled, the formation of an additive compound between cellulose and sodium hydrate is doubtful, and physics undoutedly play an important part in the phenomena.

Acids attack cotton much more than alkalis do and they decrease the strength, and "tender" the cotton. But concentrated sulphuric acid converts cellulose into tough parchment if the treatment for a few seconds is immediately followed by washing. The process can be retarded by the addition of formaldehyde and other chemicals to the acid. Nitric acid oxidises the cellulose into a number of nitro-celluloses, particulars of which Mr. Hall leaves to other books. Most acids hydrolyse cellulose; but the term "hydrocellulose" has no more definite meaning than the term "oxycellulose," which Mr. Hall might, however, have admitted into his otherwise good index. Some bacteria rapidly destroy cellulose; the fermentation—not technically utilised to any large extent—yields acetic, butyric and carbonic acids, and in addition either hydrogen or methane. The attack of cellulose by fungi and mildew has to be warded off by the use of antiseptics.

Mr. Hall surveys all these reactions with special regard to the constitution of cellulose, a problem which is being ardently studied, notably by Irvine at St. Andrews, and to their technical bearing. Special chapters deal with dyeing and with artificial silk, the production of which now exceeds the natural silk production, and celluloid. There are four artificial silk processes: a solution of nitrocellulose in alcohol and ether (collodion) is squirted into water, or wood pulp is dissolved either in cuprammonium and squirted or in caustic soda and carbon bisulphide (viscose silk)—these three silks are pure celluloses; the artificial silk obtained by acetylation is a silk acetate. Mr. Hall cannot in this volume of 228 pages go much into detail, but the machines and apparatus he describes and illustrates are by no means restricted to the laboratory; his surveys are excellent and well stocked with literature references right up to date, and the technical man will hardly find a page that does not tell him something of interest. The book is well revised, although Schönbein and Willstätter are deprived of the dieresis and Dorée of his accent.

History of the Portland Cement Industry in the United States. International Trade Press, Inc. Chicago–London. 1924.

THE greatest romance that was ever known is, we are told, the story of industrial America, and certainly not the least fascinating chapter in that strange romance, if the word may be allowed, is that which describes the rise and progress of the cement industry in that country. We are fortunate that many of those who have seen the infant grow to a robust maturity, and have guided its wayward steps through the perils that beset inexperience, are still with us to speak of their hopes and disappointments —their failures and their successes. Mr. R. W. Lesley, whose name stands first on the title page, was the first president of the Portland Cement Association, and his collaborators, Messrs. Lober and Bartlett, have long enjoyed opportunities of watching the changes that have overtaken cement manufacture, its manner of distribution, and the variety of its employment, that have metamorphosed no small portion of the appearance of the country. Thirty years ago the annual production of Portland cement in the United States was less than a million barrels: to-day it approaches, if it does not exceed, 150 millions. We may well ask how has this great work been effected, and when we have grasped the main facts, we shall be prepared to give unstinted praise to the pioneers, who had the faith and courage to fight against difficulties, and the vision and imagination to perceive what the future offered to well-concerted effort and individual endeavour.

The United States first developed a cement industry of the kind known now as "natural" cement, and about 1880, when the Portland speciality was taken up in America, was producing some two million barrels a year. Up till the beginning of this century the "natural" cement makers, assisted by importations from Europe which often took the form of ballast in sailing ships, held their own against the innovations and succumbed only after a fierce struggle. The decline however, once it set in, was exceedingly rapid. In 1900 both competitors were producing annually 8,000,000 barrels, but 10 years later the natural cement production had dwindled to below 1,000,000, while the Portland had increased to the enormous quantity of 77,000,000 barrels. How this was accomplished is the tale that Mr. Lesley tells with pride, not unmixed with amazement at the wonderful success. The natural cement makers enjoyed a monopoly and the building community, unguided by any reliable test of quality, were prepared to place implicit faith in the makers and in the brands to which they were accustomed. Specifications were rare, and when demanded showed wild differences in the type and manner of test to be applied. The price of labour was high in America, and this gave foreign competition its chance. On the other hand, the price of fuel was low, and it was on these two facts that the new competitors saw they must base their policy. Human labour must be eliminated by the use of mechanical devices, while the existence of suitable fuel determined the site for the kiln. The existence of natural gas was a kindly factor of which the constructors of rotary kilns took note. But perhaps the recognition of the value of chemistry and of scientific training played a larger part in the development than is usually acknowledged.

The value of this book is that it presents the genesis and growth of a huge industry, described from the inside by those who have borne the heat and burden of the day, and sustained the weight of the whole superstructure by their competent administration and conduct. Such a study cannot be but instructive, for whatever confidence we place in the efficacy of the various measures adopted, we cannot escape from the facts and their consequences. We can follow the improvements on the mechanical side of the industry, but perhaps equally efficacious as a promotion factor, stands the keen appreciation of the need of exact chemical knowledge, which was bound to lead to the adoption of standard specifications, a measure that has proved a most fruitful stimulus to advance.

Machine Design—Questions and Problems. By E. F. GARNER, Assistant Professor of Machine Design, Cornell University, Assoc. Mem. American Society of Mech. Engineers; and C. D. ALBERT, Professor of Machine Design, Cornell University, Member of the American Society of Mechanical Engineers. London: Chapman and Hall, Limited. [Price 7*s.* 6*d.* net.]

THIS is a type of book which has not found much vogue this side of the Atlantic, since it is wholly a compendium of students' tests in the form of problems for solution. It embodies the joint authors' experience as teachers of machine design in the Engineering College of Cornell University. For its complete, or shall we say peculiar, enjoyment, it should be studied alongside of Kimball and Barr's "Elements of Machine Design," on which it is based, though not exclusively. It has a twofold purpose—namely, to put to practical test the student's grasp of the various features of the subject and of the *formulæ* employed, and to confine the problems to the practical subjects of everyday requirements.

There are upwards of 230 problems, covering 136 text pages, each numbered and a decimal-point added. The first part of the number denotes the article in the text in which the larger part of the information on the problem proposed may be found, the decimal figure being the actual number of the one or more problems concerned. This, so to speak, coded system is intended to facilitate reference to the cognate features in Kimball and Barr's book, and to simplify the teacher's task in apportioning the homework for the class.

The text throughout is free from hyperbole and terse, and, so far as we have tested it, is generally complete within the subject-matter of the chapter concerned. A few dimensioned sketches are given and answers to some problems. Construction, and shop practice giving effect to it, is discussed, apparently with the object of developing the student's interest in, and acquaintance with, up-to-date workshop methods.

The 20 chapters of the book represent as many divisions of the subject-matter, and range from explanations and definitions of principles of design and what may be cited as basic points (these covering the first three chapters), through the various components of machine design and construction, provision for lubrication, friction, fastenings, forms of transmission, and close with a short series of questions on balancing. As Dr. Akimoff's balancing machine is specifically mentioned, it would be useful

to mention also the Norton balancer, which is very much more used in this country; and perhaps, too, reference ought to be made to Dr. F. W. Lanchester's balancer as a commercial asset to certain motor-cars. Problems of balancing, especially the dynamic balancing of high-speed components, are among the most important to-day, and deserve to be more adequately treated than is suggested by the space in this work.

An appendix of *formulæ* and the usual "short cut" tables, &c., conclude the work, which, it may be added, has but few colloquial expressions and phrases redolent of the soil and shows an acquaintance with the researches and *data* of students on this side.

BUCKET DREDGE FOR ALLUVIAL GOLD.

No great change has been made during this century in the general lines of mining dredges, but considerable improvements have been and still are being introduced in material details. The efficiency of a mining dredge has, indeed, so direct a bearing on the profits of its owners that it is only natural for whatever can reduce its costs of working to receive even keener attention than would be attracted by similar improvements in harbour and reclamation dredges, the results of which may be merely ancillary to much larger work. The tendency to pursue every possible device in the design of dredges for reducing the costs, both of working and of repairs, even in face of increased first cost, seems partly to have caused and partly to have been assisted by the practice of having most dredges designed in accordance with local requirements by a consulting engineer with special experience of mining by dredging. One obvious advantage of this course over that of calling for tenders to a general specification, is that competing makers do not need, and, in fact, are unable to tender for some standard pattern of their own, with a view to a low first cost, and new modifications, which affect the still more-important working costs, get tried more rapidly. The evolution of dredges, especially for British users, was certainly delayed at the beginning of the century by the considerable number left over from the transient boom in alluvial gold mining in New Zealand at the end of last century. American practice, however, was not handicapped similarly, and of recent years British designers have caught up with American, and seem to be producing dredges of equal and sometimes superior efficiency for use not only by British but foreign users.

A type of dredge of which the use is steadily maintained is the ladder dredge with close-connected buckets, furnished with concentrating appliances, but dependent for its small amount of locomotion on being hauled by head and side lines. We illustrate on Plate XLVI one of the most recent of these dredges, which has been designed by Messrs. F. W. Payne and Son, of 62, London Wall, for the service of the Nus River Gold Mines, Limited, on their river and flats in the Republic of Colombia. It will be remembered that this type of dredge consists essentially of a hull with an inclined steel beam or ladder pivoted about a horizontal axis and carrying an endless chain of buckets by which the gravels or sands to be worked are excavated and raised, the depth of working being determined by the inclination of the ladder. The spoil is delivered to and treated on concentrating plant of such extent as is proportionate to the aggregate delivery of the buckets, and the tailings are returned to the water. Bearing in mind the shallowness of many and perhaps of most of the waters that are dredged, the considerable volume and weight of the necessary superstructure and its contents, and the consequent need for well-controlled working in waters that are usually turbid and gritty, a successfully designed dredge for such purposes has in a high degree to combine strength and accuracy with robustness. The low values of most of the material to be worked, with the increasingly high cost of labour in most parts of the world, makes economy of operation also of material importance. It will be seen that in each of these respects the dredge under notice includes details of interest and value. Its design also gives it remarkable stiffness in the presence of a high superstructure, and enables a large volume of machinery to be borne on a smaller hull than would be required in older designs.

The general arrangement of the hull and its equipment is shown in Fig. 1 by an elevation with the port side framing removed, and in Fig. 2 by a sectional plan. The hull, 100 ft. long by 50 ft. wide by 9 ft. deep, is built of steel plates, with channel and angle-steel frames, and the superstructure is also of steel, and amply anchored to the hull. Except for the main pumps the entire equipment is on or above deck. The machinery for dredging operations, prime motors and auxiliaries are fitted on the deck itself, a control or pilot house being provided above the hoisting machinery at a height of 14 ft. 3 in. above deck, from which the dredging buckets can be seen. By means of rods and levers, the operation of all the hoisting and other gear for moving the dredge and operating the dredging mechanism is concentrated in this house under the control of one man. At a height of 28 ft. 6 in. from the deck gantries are provided over the bows and amidships along the centre line of the vessel, the girders that carry them extending continuously from over the bows to over the stern, where they are connected to the vertical members of a frame that takes the pull of lifting appliances in connection with the concentration plant. This frame extends upwards to a height of 44 ft. 6 in. above the deck, at which height the midships gantry is provided with a top frame, which is tied to the vertical members of the frame over the stern, and to similar members of a frame formed over the bow gantry. The gantries are stiffened by webs formed of plates and sections as shown, and, in addition to their numerous anchorages to the hull, the several elements of the superstructure that have been described are strutted and tied together from end to end of the vessel, especially along either side of the centre line, along which lie the strains of the buckets and of the concentrating tables and tailings elevator. In this way, according to a practice introduced by Messrs. Payne in recent years, the hull is strengthened and stiffened along the centre line by what is practically a continuous superstructure from end to end; a matter of considerable importance in view of the large capacities of modern dredgers and the considerable length of their hulls, which often much exceeds that of the present dredge.

Under deck the hull is divided into 20 water-tight compartments, any one (and in most circumstances more than one) of which can be flooded without materially reducing the stability of the vessel against overturning.

The excavating and lifting chain consists of 59 close-connected buckets in cast manganese-steel, each of 9 cub. ft. capacity, passing over manganese-steel tumblers, the bottom one being cylindrical and of 4 ft. 9 in. diameter by 2 ft. 6 in. face, and the top or driving tumbler being of hexagonal section 2 ft. 2 in. diameter by 2 ft. 5 in. face, with outer wearing faces bolted to the body, so as to be replaceable when necessary. A later design for the driving tumbler, enabling wear to be taken up continuously, is described below. The top tumbler, through which the buckets are driven, revolves on a shaft 1 ft. 3 in. diameter (Figs. 16 and 17), carried in bearings arranged on the midships gantry, and the bottom tumbler is keyed to a shaft 1 ft. 1 in. diameter across the bottom of the ladder. All bearings are accurately machined and grease lubricated, the bottom ones being under forced lubrication and fitted with grease-locking and grit-excluding arrangements, which are fitted also on the ladder rollers and other bearings that work under dirty conditions. A view of this bearing is shown in Figs. 18 and 19. The top or driving tumbler revolves at 3·5 to 4 r.p.m., driven through gearing off a pulley, which revolves at 100 r.p.m. and is driven by a belt off one of the main engines. The bucket chain is thrown in and out of gear by a powerful internal clutch on the driving pulley, which, like the rest of the dredging mechanism, is operated by a lever in the control room. The buckets travel at the rate of 22 to 24 per minute, giving an output of about 250 yards per hour or about 150,000 yards per month.

The ladder on which the chain of buckets is carried is a braced structure 65 ft. long between centres by 5 ft. 4 in. wide. It consists of two webs built up of steel plates, angles and channels, and carries a line of rollers along its upper edge, on which the buckets travel. The bottom tumbler, which is in fact only a large roller, is carried in 1 ft. 2-in. machined bearings, which are themselves carried in heavy steel castings with soles extending along the ladder plates, to which they are riveted, so as to ensure a rigid support for the tumbler. A fixed jib, worked off a drum of the mooring winch, is provided for lifting this tumbler when necessary. The bottom end of the ladder is also fitted with a guard to prevent the buckets from getting over the side of the ladder should they at any time get thrown off. With characteristic caution, a timber face is provided on this guard to receive the impact of refractory buckets. At its upper end the ladder is carried on an 8-in. shaft in bearings arranged in the midships gantry, and towards the lower end has a shaft through which it is connected to a lifting rope. This rope passes over grease-lubricated lifting sheaves on the gantry over the bows, and is led through a single guide sheave to the ladder-hoisting winch. At an angle of 45 deg. the ladder excavates to a depth of 22 ft.

The ladder-hoisting winch, which is fixed on the deck, is arranged with the axis of the drum parallel to the ladder, instead of transverse, as is usual, thus giving a more direct pull on the hoisting rope. It is driven by a belt off a countershaft on the mooring winch driven off one of the main engines, and on a second motion shaft has reversing gear and an auxiliary band brake. The drum of the winch is 3 ft. diameter, and has brake drums in one with it on either side, so avoiding any danger through accident to the gear. The main brakes, which act on these drums, are arranged on the compound system, of which Fig. 20, on page 698, gives a sketch. In this system the pull on the band round the first or pilot brake, due to the frictional resistance between the band and the drum under the braking force, is transmitted in series to the band of the second brake through a brake shaft and levers. These, moreover, are so proportioned and situated that the motion given per unit lift of the brake rod to the pins connecting the bands with the brake levers decreases continuously as the braking operation proceeds, and the braking effect is thus multiplied as with a toggle. The band and lever of the second brake drum are shown dotted in Fig. 20.

The mooring winch, also fixed on deck, but transversely to the fore and aft line, is shown on Figs. 3, 4, 5, 6 and 7. It has seven drums, one for operating the head-line, four for the side-lines, one for lifting out the bottom tumbler when necessary, and one used at present for working a swinging jib crane provided on the port bow, but available in need for operating a spud for excavating. The general lines and most of the principal details of the design are sufficiently evident from the figures. The head-line drum is fitted with a compound brake of the same type as on the ladder-hoisting winch, and the others with band brakes of an ordinary design.

A Seymour type clutch is fitted on the first motion shaft, and powerful internal clutches with Ferodo-lined bands on the several winch drums, that on the head line drum being overhung outside the gear wheel of the drum. The winch is carried on timbers and provided with a platform, to enable attention to be given when required on the same side as the large gear wheels. For the same reason long pipes are fitted to the lubricators on all bearings on that side of the winch; and generally the design of all the plant is contrived with a special eye to the safety of the operators. It will be observed that the bearings throughout the winch are designed with special care to ensure constant and adequate lubrication.

Every operation for which winches are used is done by a separate lever in the control or pilot house. A splash plate is provided on the starboard side to protect the winches from the splash of the buckets.

Before passing from the dredging and operating appliances Messrs. Payne's latest design of driving tumbler may be described. Although it was not completed in time to be embodied in the present dredge, it is now being fitted in others that are being supplied to owners abroad, and appears to show a distinct advance over any previous construction. In a dredge of the type in question with ordinary tumblers, when the chain of buckets is new and correctly fitted it is driven with the surface of each link lying for the most part on the flat of each hexagon in turn, and the wear is distributed over the surface of the tumbler more or less uniformly. Wear, however, occurs both between the pins that connect the links of the chain and the bushes in which they are mounted. The pitch of the chain is thus increased, and it becomes slack in the tumbler, so that the whole of the power that it transmits has ultimately to come on the corners on the tumbler, which wear rapidly in consequence and the tumbler becomes unserviceable. As described above, the driving tumbler in the present dredge has removable faces, and when they have worn sufficiently they can be replaced by others of sufficiently greater depth to fit the chain; but until the wear on the pins and bushes has lengthened the chain sufficiently to enable it to work over the next deeper size of face that has been supplied, the excessive wear on the tumbler goes on as before. In the new design the tumbler is made with recesses in the centre of each face to accommodate corner pieces in manganese steel, and on the occurrence of any wear whatever these corner pieces can be pushed outwards and held so as to fit the worn chain, thus in effect increasing the pitch of the tumbler. Fig. 8 shows an outside view of a tumbler so fitted, and Fig. 9 a sectional elevation with the corner pieces removed, Figs. 13, 14 and 15 a plan and cross sections of the corner pieces, and Figs. 10, 11 and 12 a longitudinal section of the entire tumbler and its fittings with cross-sections of wedges. Figs. 16 and 17 show a view of the tumbler shaft with the tumbler removed. It will be seen from Fig. 8 that the loose corner pieces which continue the original faces of the hexagonal design are held within the recesses cast in the centre of the tumbler faces by a series of steel clamps bolted together with 3¼-in. nickel-chrome steel bolts. The 1½-in. set screws in the centre of each of these clamps are for convenience of mounting, and when they have served their purpose can be replaced by lifting eyes. The corner pieces, seen in the cross sections (Figs. 14 and 15), are cored out for lightness where convenient, and machined on the back to a taper

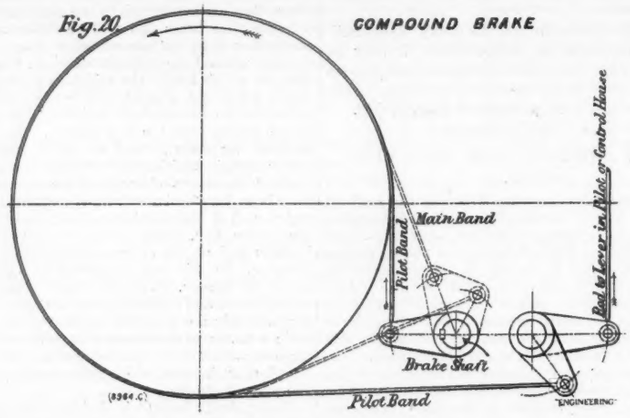
of ½ in. to the foot. A set of 19 cast-steel wedge blocks are machined together to the same taper, thus forming a continuous wedge in 19 segments; the form of these blocks, of which the larger ones are also lightened as shown, is seen in Fig. 10 and in the small cross sections (Figs. 11 and 12). The smallest sizes of these blocks (in the design reproduced the first seven), together with a 6-in. distance piece, are threaded over a 2-in. bolt with a thread long enough to allow a full 12-in. draw; the bolt is drawn up by a nut against a cast-steel flange and the wedge blocks, which press against the underside of the tumbler corner pieces. Both the tumbler body and the corner pieces have extensions serving to provide increased bearing surfaces and backing for the clamps; the precise forms can be seen from the various views in Figs. 8, 9, 10 and 13. At any time the bolts on the clamps can be slackened, and the distance piece behind the wedge-blocks forced forward along the bolt by means of the nuts, thus also pushing the wedge blocks forward along the bolt and the corner piece outwards from the tumbler shaft. When this adjustment has gone so far as to extrude all or as much as is thought desirable of the first wedge-block, it can be removed, and the next largest block of the set can be inserted at the driving end. In this way the pitch of the tumbler can be increased continuously to an extent limited only by the extent to which the tumbler casting allows the position of the clamps to be expanded. Application has been made for letters patent for this design.

After passing over the driving tumbler the buckets deliver their spoil into a chute leading to an inclined rotary screen driven by a friction drive at the upper end at a speed of 7 r.p.m. off the other main engine. This screen is 7 ft. 6 in. diameter by 42 ft. long, carried on turned cast steel rollers within cast steel roller paths, and retained in place by a conical thrust roller on the lower roller path. The wash passes through holes in the screen, varying from $\frac{5}{16}$ in. to $\frac{3}{8}$ in. diameter, into a catchment box immediately below, where the first gold saving is effected, and such small quantity of the spoil as failed to be delivered into the chute or to pass from it into the screen falls into a "save-all" or miniature concentrating launder below, where, as in the catchment box, the usual methods of saving are applied, the tailings from the "save-all" being delivered overside. The screen is furnished with a water supply from a 12-in. centrifugal pump delivering 3,000 gallons per minute under a pressure of 45 ft., which passes out through two rows of $\frac{3}{4}$-in. brass nozzles screwed at 4 in. pitch into a lapwelded steel pipe 12 in. diameter by ¼ in. thick, which extends inside the screen along the top. From the catchment box the wash passes on to transverse launders on each side of the screen, from which it is distributed over three pairs of concentrating tables running fore and aft on each side of the screen, and providing an aggregate area of 2,000 sq. ft. of concentrating surface. The tables are supplied with dressing water from another centrifugal pump, also of a capacity of 3,000 gallons per minute; the supply for each table is controlled by a separate plug cock, and before flowing on to the tables proper the wash passes through "boil boxes" or traps arranged at their heads. In these boxes the wash passes under vertical diaphragms, each of which is pivoted on a horizontal axis in the direction of flow, and can therefore be adjusted as required so as to distribute the wash uniformly over the head of the table on to which it delivers. According to the character of the wash riffles, matting, and mercurial catchments are used for saving the gold. The character of the wash also determines the angle at which the tables are to be worked. To enable this inclination to be readily adjusted each pair of tables is pivoted at the upper end and supported at points about two-thirds of its length down by 1 in. diameter wire ropes on differential pulley blocks anchored to the vertical frame over the stern, which as has been already seen is tied to the midships and bow gantries and to the hull. The resilience of this rope support is said to enhance the concentrating efficiency of the tables by setting up a slight but rapid vibratory action. To protect the tables, with their possibly valuable burden, from surreptitious visits by unauthorised persons, the tables are housed in heavy expanded metal and brightly illuminated, so that no one can approach them without being visible from a considerable distance. This method has been tried successfully on land, where it has been found superior to shedding, which necessarily provides cover not only for the concentrates but for unlawful collectors.

The oversize from the screen is regarded as worthless, except perhaps when it can be used as washed ballast. It is delivered on to a belt elevator 80 ft. long between centres of pulleys with a rubber belt 38 in. wide, driven by a single wire rope $\frac{3}{8}$ in. diameter from a countershaft run by a belt off the pumping engine.

The water supplies for the screen and the tables are provided by the 12-in. and 14-in. centrifugal pumps mentioned above, which run on one shaft below deck. They are driven by belt off the same engine as drives the screen and tailings elevator. On its way to the screen the water passes through a vertical tubular cooler, where it serves to cool the water that has passed through the cylinder jackets of the engines, and can thus be circulated indefinitely; a matter of consequence, as the river water is not clean.

Fig. 20. COMPOUND BRAKE



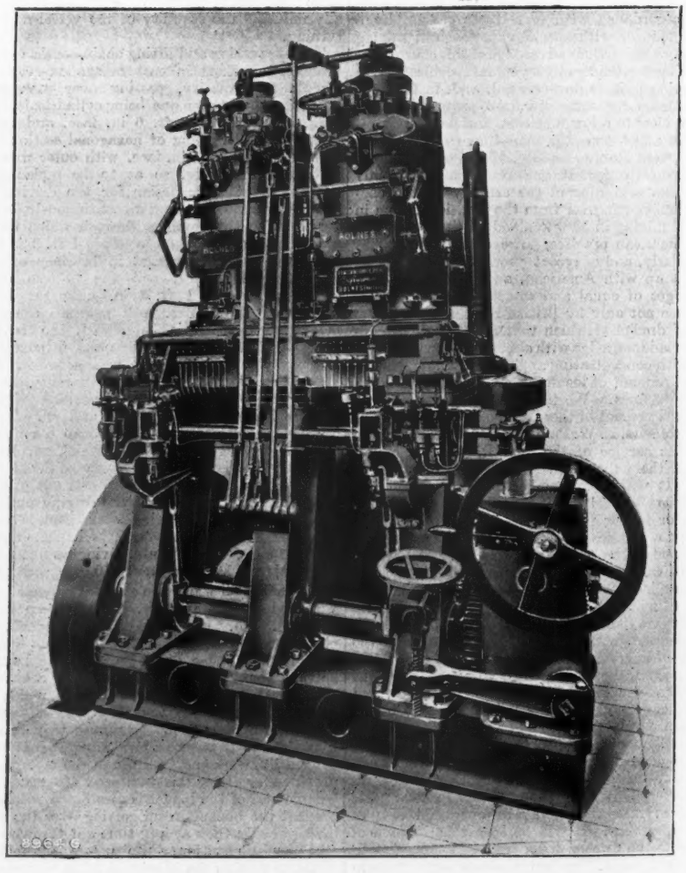


FIG. 21. LADDER AND WINCH ENGINE.

The whole of the plant on the dredge is driven by Bolnes semi-Diesel oil engines of the standard type, a description of which has already been given in these columns (January 21, 1921). It will be remembered that this is a vertical open-fronted engine with connecting rod, slipper and guide as in a steam engine, the moving parts being left open and easily accessible for examination and adjustment by using hollow cast-iron supporting columns instead of the crankcase for compressing the scavenging air. The engine that drives the bucket ladder and the winch develops 170 brake horse-power at 200 r.p.m., and the reversing gear is operated by compressed air. A view of this engine is seen in Fig. 21. It is fitted with fuel and lubricating pumps of the Bolnes standard type, two cooling pumps, a bilge pump, and an air-compressor pump, thus being a complete unit independent of the auxiliaries. The engine for driving the screen, centrifugal pumps, and tailings elevation is a unit of similar design, which develops 120 brake horse-power at 250 r.p.m. The auxiliary plant consists of an auxiliary air compressor, electric light generator and a general service pump, and is driven off an overhead countershaft by a single cylinder, hand starting Bolnes engine, which develops 10 brake horse-power at 480 r.p.m. It is arranged to be started either with air in the usual way, or in the alternative by means of a blow lamp. The oil from the bearings is circulated and thus partially cooled. The cooling water pumps draw from a tank, to which after passing through the cylinder jackets it is returned by way of the vertical cooler already mentioned, the

screen water providing an abundant supply for cooling purposes, which is particularly useful in view of the high temperature of the river water in Colombia. The tank is large enough to enable the engines to run for a long time even if the centrifugal pumps are not running.

The vessel is well provided with lifting tackle. In addition to jibs, it has a 15-ton traveller over the tumbler framing, which can traverse about 6 ft. over the side of the dredge, and thus pick up weights from the shore. It has likewise a traveller (not shown in the figures) arranged over the winches and the buckets, which can serve for the same purpose.

We are indebted to Messrs. Payne for the particulars of the plant, and to the contractor for the dredge, Mr. Arthur R. Brown, of 54, New Bond Street, for the photograph of the Bolnes engine.

THE RUSSIAN RAILWAYS.

THE Russian railways in full activity before the War had a total length of 41,460 miles. After the War about 3,800 miles were transferred to Poland, whilst about 3,100 miles were assigned to Roumania, Esthonia, Latvia and Lithuania. Russia, therefore, lost about 6,900 miles of her pre-war lines, the greater part of which, namely, about 6,200 miles, had been previously under State ownership. There thus remained to Russia at the time when the present Soviet Government came into power 34,560 miles of railways, of which 21,000 miles had been State railways and 13,560 miles were formerly owned by private companies. We may here remark that the railways of Finland have always been under Finnish management; the track as far as the frontier station of Belostrof was alone under Russian jurisdiction. For this reason the War has brought about no change as far as the Finnish railways are concerned. The following are the State-owned and the privately-owned Russian railways as they stood previous to the War.

STATE RAILWAYS.

	Miles		Miles
1. Alexandrovsky ..	640	12. Samara-Zlatoust ..	780
2. Amur	1,300	13. Central Asia ..	1,450
3. Ekaterinenskaia ..	1,600	14. Sizran-Wiazma ..	820
4. Transbaikal ..	1,120	15. Northern	1,870
5. Transcaucasus ..	1,140	16. North-Western (a part)	280
6. Libava-Romenskaia	590	17. Taschkent ..	1,300
7. Moscow - Kursk - Nijni Novgorod ..	690	18. Tomsk	1,130
8. Petrograd - Moscow (Nicolas)	840	19. Oussouriyskaia ..	520
9. Omsk	1,590	20. South-Western ..	2,690
10. Perm	1,320	21. Southern	1,950
11. Riga-Orel	590	22. Murmansk ..	680
		Total ..	24,890

PRIVATE RAILWAYS.

	Miles		Miles
1. Altay	470	16. Moscow-Kieff-Voronej	1,680
2. Armavir-Touapse	170	17. Novozybkoff Vicinal	70
3. Atchinsk-Minoussinsk	270	18. Podolia	398
4. Bessarabia ..	84	19. Riazan-Ouralsk ..	2,500
5. Bouchara	345	20. Semiretchenskaia ..	238
6. Belgorod-Soumi ..	84	21. Donetz-North ..	475
7. Vladicaucase ..	1,890	22. Tokmakskala ..	75
8. Volga-Bougoulminskaia	340	23. Troitzkaia ..	298
9. Eysk	82	24. Fergana	169
10. Kahetia	100	25. Black Sea-Kuban ..	243
11. Koltchouginskaia	182	26. South-Eastern ..	2,000
12. Kouloundzinskaia	182	27. Southern Vicinal Lines	420
13. Moscow - Vindau - Rybinsk	1,500	28. Ural West ..	284
14. Moscow Vicinal Lines	187	29. Ural North-East ..	294
15. Moscow-Kazan ..	1,540		
		Total ..	16,570

The large number of State railways and of private companies, 22 and 29 respectively, forms a striking feature of the Russian railway organisation. Before the War the industrial undertakings of the country had reached a very high degree of efficiency and were being extensively developed; as a consequence, about 20 new private railway companies were formed in a comparatively short period previous to the War, for the construction of a further number of small railway lines, the hope of the promoters being to extend their length gradually following the continued development of the agricultural and other industries of the country. The greater part of the new companies we here refer to had no time, owing to the War, to start work on their concessions, and the lines they contemplated building are naturally not included in the foregoing list, which does not include either the narrow gauge lines of purely local interest. This activity in the matter of private railway enterprise is attributable partly to the fact that the State during the same period undertook practically no railway extension work and was satisfied to leave this in the hands of private concerns. Before the war the management of all the Russian railway systems was centralised at the Ministry of Railways and Communications, Petrograd, and the work this entailed was frequently found to be almost overwhelming. That it was complicated in the extreme can well be imagined, considering the number of different concerns and the differences in the gauges. Many attempts had been made from time to time to divide up the systems and their management into what may be termed "geographical zones," following in this the methods which obtain in other countries. These attempts, however, never matured. During the War the deficiencies and difficulties attendant upon the Russian railway organisation were made particularly apparent and became accentuated as the War progressed; it prevented the systems from displaying all the required activity as would have been the case had they been divided up into groups, each suitably managed by an independent board. Both the State railways and those operated by private companies were generally subject to the same tariff regulations and the same commercial and technical operating conditions. They differed from one another principally in regard to their financial measures. The privately-owned systems, however, enjoyed a certain degree of independence with reference to the organisation and methods of operation.

As has been the case with every other nation, the whole life and progress of Russia has depended upon the development of her railway systems in recent decades. In the matter of length of lines to area of the country, Russia has always been much behind all other European nations. On the other hand, in many other respects, such as types of rolling-stock, travelling conditions, Russia before the War compared favourably with several European countries, and took precedence over others in regard to low tariff conditions.

There were in service in Russia previous to the revolution about 20,500 engines, 20,000 passenger carriages, and 570,000 goods wagons. At the present time, it is stated, the railways, now under Soviet management, own about 17,000 engines, 17,500 passenger carriages, and 460,000 goods wagons, including 14,000 tank wagons for the transport of crude oil. These numbers, however, taken alone, do not give an accurate impression concerning the Russian rolling-stock position. It is indeed asserted that of the latter numbers 2,000 engines, 3,000 passenger carriages, and about 140,000 goods wagons only are, at the present time, still capable of service—a limited service at best; by far the greater portion of all the rolling-stock units require overhauling, and more or less extensive repairs. Overhauling and repairs are not carried out, and the whole of the rolling-stock continues to deteriorate as the days go by; it is kept in operation until it becomes absolutely unserviceable. Repair and maintenance work is practically nil, also as concerns the permanent way, the railway buildings, signalling plant, and all other equipment. The travelling speeds are reduced of a necessity, stoppages at stations are lengthened, and on certain lines there is no longer any traffic. Defective sleepers on the principal lines are removed and replaced to an extent which varies between 10 and 30 per cent. of the quantity necessary to ensure safe working. The average daily run of a locomotive is said not to exceed 30 miles at the present time, thus giving a total service per day of 60,000 engine-miles for the 2,000 engines, a service which, by all accounts we have received, is likely to decrease as time goes on, bringing back the country in gradual stages down to the railway facilities—or lack of facilities—which obtained half a century ago, this being attended with increasing stagnation in all branches of agriculture, commerce and industry.

The procedure now followed is to operate the main railway systems to the detriment of what are considered the less important ones. Committees are appointed whose duty it is to travel on the latter systems, and to cause to be removed therefrom any material which can be used to patch up the main systems. This material includes rails, sleepers, points and crossings, signalling apparatus, and other plant. As an inevitable consequence, a number of lines have had to be closed. Traffic is frequently impeded on others owing to lack of fuel. The main railway systems, in spite of the greater attention which is given to them by the Government authorities, do not appear to be operated very satisfactorily. According to official statements, their reduced activity is kept up to some extent by means of a State subsidy which, in 1924, amounted to 165,000,000 roubles tchervonetz.* Notwithstanding this, wages are said to be paid very irregularly.

It would appear that the ultimate reconditioning of the Russian railways is only possible with the assistance of foreign countries, in the shape of financial help and the supply of the necessary materials of all kinds. The term "reconditioning" in the present instance simply means the re-establishment of the Russian railways in the position they occupied previous to the revolution. The work of reconstruction would have to commence, so it would seem, not at the termini within the country, but at the outskirts, at the harbour and frontier stations where the required material of foreign origin would have to enter, the lines being continued thence to the principal centres until the 34,560 miles of railways, with all the bridges, plant, appliances and rolling-stock, are again in a position to carry the equivalent of pre-revolution traffic. One of the difficulties claiming attention and to be solved early in the day will be so to dispose of the damaged rolling-stock still capable of service after overhauling and repair, that it does not delay permanent-way reconstruction. For the time being it would appear that this rolling-stock forms a serious encumbrance on sidings and on portions of the actual long-distance tracks. The Russian railway systems owned 51 large works for repair and maintenance work, originally equipped with a variety of machinery and plant. In the year 1913–14 they gave occupation to 84,000 men; their annual capacity was the repair of 4,300 engines, 4,400 passenger carriages, and close upon 60,000 goods wagons. They, moreover, supplied numbers of spare parts, also various fittings for stations and buildings. These repair shops have been stripped of a great part of their equipment and would require new electric-power plant, machine tools, lifting gear, &c. Extensive new depots and repair shops fully equipped would have to be provided throughout the country to cope with the work, together, most probably, with dwellings and food supplies for the men in charge.

As will be seen from this brief review, the problem of the Russian railways has become most acute. Their reconstruction will involve the utilisation to the greatest possible extent of all the means of communication available in the country, including road transport by lorries, also river transport, and this latter would be greatly facilitated by a system of canals. A canal joining the Volga and the Don, among other works of this nature, would prove, very probably, a most valuable development. The sleepers, to take only one of the essential items for the work under consideration, will now require to be brought from a distance, since the forests which were comparatively close to many lines are said to have been cut down; this will imply the construction of feeder, narrow-gauge lines connecting up distant forest districts with the main railways. It is interesting to note in this connection that on the Russian railways the sleepers number 2,350 per mile of track. The Russian steel works in their present state of disorganisation would be unable to deal with the necessary supply of rails.

As is well known, a very large proportion of the main Russian railways are on the wide 5-ft. gauge, but this difference from the normal 4 ft. 8½ in. gauge of the neighbouring countries had not materially hampered the commercial intercourse carried on before the War between Russia and those countries, since, on the one hand, a very large portion of her heavy or bulky raw-material exports was effected by sea. Moreover, in the case of goods transport by rail, transhipment at the frontier towns was combined with the necessary customs formalities, which very frequently take up as much time as does the actual transhipment. It was possible generally to combine the two series of operations. Nevertheless, the question of reducing the broad gauge of many of the Russian railway systems to bring it into line with the practically universal normal gauge was one which has occupied Russian technical railway experts for many years past. They had always shrunk from the heavy expenditure this would have entailed to the country. To an outside observer it would appear that the present Russian Government were indirectly paving the way, in a rather wasteful manner, for some such change of gauge transformation, since, by all accounts, there may be, sooner or later, no serviceable lines and rolling-stock left in the country. Every single item seems likely eventually to have to be scrapped or rebuilt, and there would thus be an opportunity for standardising the gauge, should this be desired, when the time comes.

* 1 rouble tchervonetz is now worth nominally about 48 kopecks, as against 100 kopecks for the pre-revolution value of the silver rouble.

THE VULCAN ROADLESS VEHICLE—ERRATUM.—We regret that in our description of this vehicle in our issue of May 22 we referred to the track as being of the Kegresse system. Actually, the track, as stated in the description which we published, is made up entirely of stamped steel links. It is therefore dissimilar from, and has no connection with, the Kegresse system, which utilises a rubber belt type of track.

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W. 1, announces that the Department of Sanitary Works of the Nation, in Argentina, invite tenders, to be presented in Buenos Aires not later than July 23, 1925, for the supply of two sets of centrifugal pumps, driven by means of internal-combustion engines, for use in connection with the water supply of Rio Gallegos, Santa Cruz.—The Egyptian Ministry of the Interior invite tenders, to be presented at Cairo not later than July 2, for material in connection with new waterworks to be constructed at Fikria. All inquiries regarding these tenders should be addressed to the Department of Overseas Trade.

SELF-CONTAINED HEATER FOR FOUNDRY AND METALLURGICAL USE.

CONSTRUCTED BY MESSRS. INTERNATIONAL PROCESSES, LIMITED, ENGINEERS, LONDON.

Fig. 1. SECTION a.b.

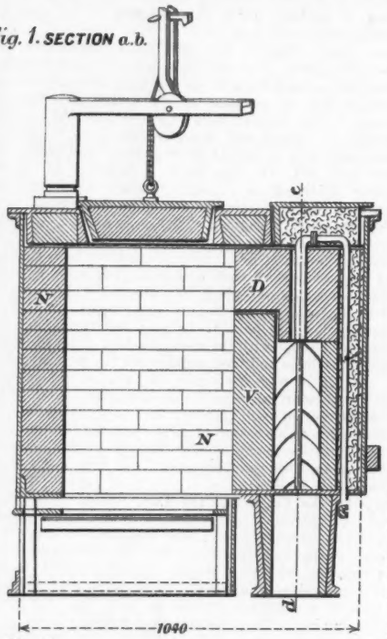
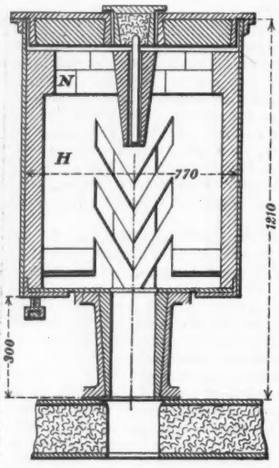


Fig. 2. SECTION d.e



Opening into Mould

Fig. 3.

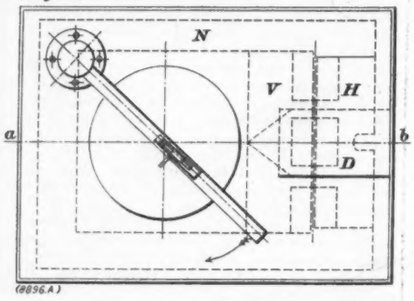


Fig. 4.

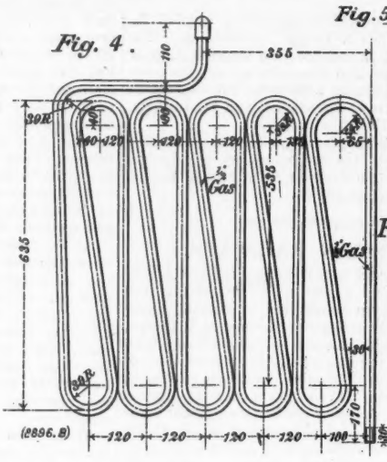


Fig. 5.

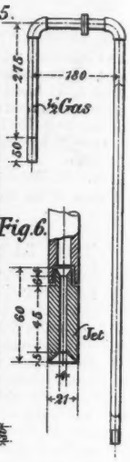


Fig. 6.

Fig. 7. BRICK P. 6 OFF. WEIGHT 12 KG.

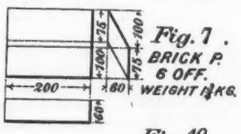


Fig. 8. BRICK R. 2 OFF. WEIGHT 11 KG.

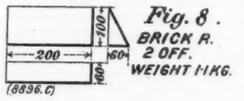


Fig. 9. BRICK D. 1 OFF. WEIGHT ABOUT 17 KG.

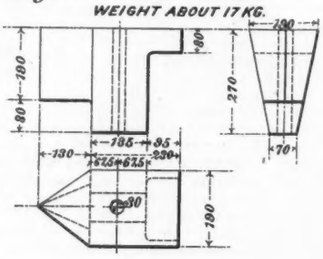
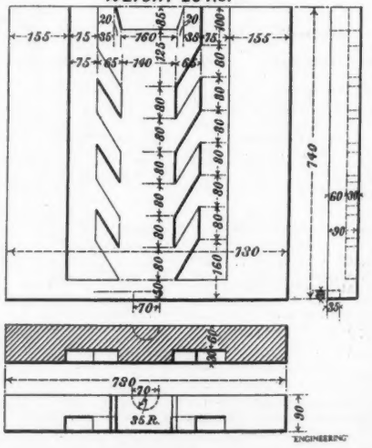


Fig. 10. BRICK H. 1 OFF. WEIGHT 26 KG.


155
75
35
20
35
760
35
20
35
75
155
75
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140
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125
65
80
80
80

SELF-CONTAINED HEATER FOR FOUNDRY USE.

CONSTRUCTED BY MESSRS. INTERNATIONAL PROCESSES, LIMITED, ENGINEERS, LONDON.

Fig. 12. SECTION A.B.

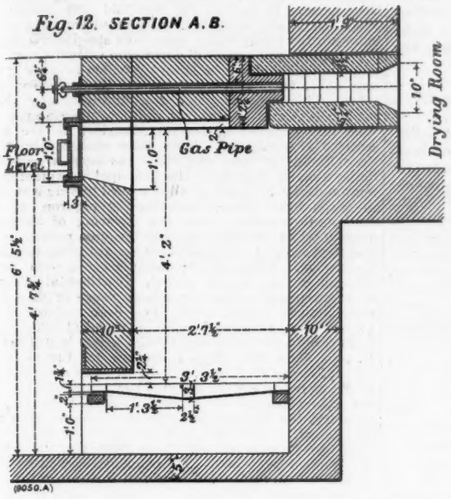


Fig. 13. SECTION C.D.

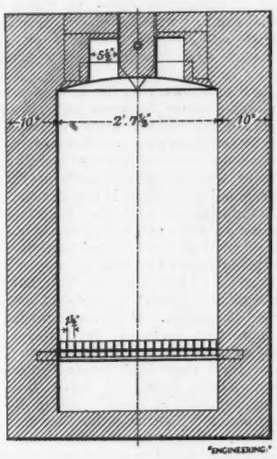
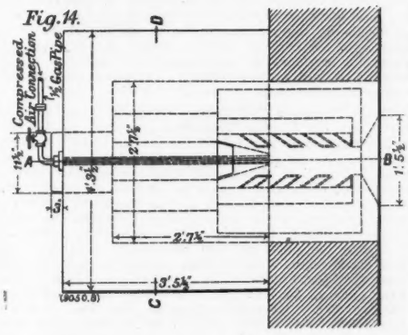


Fig. 14.



the drying of moulds. It may, of course, be operated in connected with a drying stove, and is utilised in that way by Messrs. Edgar Allen and Co., Limited, of Sheffield. It may, however, be applied direct to the mould, and as an example of its efficiency for this work the case of the moulds for a large casting may be quoted; for the drying of which one Oehm's heater required 4 cwt of fuel, and completed the work in 8 hours, as compared with two ordinary fan-driven portable furnaces, which required 1 ton 13 cwt. of fuel and took 78 hours. Messrs. Cammell Laird and Co. have utilised these heaters at their Grimesthorpe Works for mould drying, and state that the coke consumed is about one-quarter of that required by their other stoves. Messrs. Edgar Allen, in connection with the installation referred to above, state that when used in connection with a drying stove an appreciable saving is shown in the cost of operation. They also state that the drying is done more satisfactorily. The latter fact illustrates one of the important claims for the heater made by the makers. They state that if all the orifices in the mould are carefully closed, the high pressure of the hot blast drives the steam formed into the body of the sand and right through it. The blacking is pressed firmly down, and the mould remains porous, and in good condition for casting. Very little care ensures that the mould is not burned. When the air coming from the mould is dry, which is easily ascertained, the mould is also dry, and no further heating is necessary.

When the element is applied to the heating of large ladles or ingot head moulds, a cover is made to fit the ladle or mould with an opening in the top through which the gases can pass. The element is placed on top. If the ladle is very deep, a pipe can be hung under the cover to lead the gases to within, say, 2 ft. from the bottom. For drying stoves a connection as direct as possible and with easy bends is made from the heater outlet to the stove. The gases should be led along the floor of the stove through perforated pipes, placed about 6 in. above the floor level. The heater is built in three sizes, capable of producing respectively 165,000, 330,000 and 560,000 B.Th.U. per hour. The smallest unit weighs 3½ cwt., and occupies a floor space of 25 in. by 25 in., and the largest weighs 1¼ tons, and occupies 45 in. by 45 in., these dimensions relating to the type of heater illustrated in Figs. 1 to 11. A modified form has recently been introduced with a horizontal gas outlet. This is illustrated in Figs. 12 to 14. This form has been specially designed as a permanent heating unit for mould and core drying stoves. The horizontal outlet is found to give better results for this particular application, while the new heater has a larger fuel bed, so that less frequent stoking and attention are required. The fuel consumption of this new model is 60 to 70 lbs. per hour, a 6 mm. jet being employed as compared with 5 mm. for the largest size of the portable heater. The appliance is manufactured by Messrs. International Processes, Limited, of Basildon House, 7, Moorgate, London, E.C.2.

THE LATE PROFESSOR MÜLLER-BRESLAU.

THE news of the death of Professor Müller-Breslau will cause regret far beyond the boundaries of Germany. He was an honorary member of the Royal Academy of Science of Sweden, the American Academy of Arts and Sciences, and many other distinguished bodies. He died on April 23 in Charlottenburg, where he had worked and taught for more than forty years.

Born at Breslau on May 30, 1851, Heinrich Müller had originally thought of a military career. As a subaltern in the engineering division he took part in the Franco-German War of 1870 and 1871. He then returned to college, and was by 1875 established as a civil engineer in Berlin and already known as an original investigator and writer under the name of Müller-Breslau. In 1883 he was called to Hanover as Professor of Engineering at the Technical High School, and when, in 1888, Emily Winkler's chair for statics and building construction at the Technical High School of Charlottenburg–Berlin became vacant, Müller's selection as Winkler's successor was a matter of course. Statics, bridge construction, and the strength of materials are hardly subjects in which a professor is likely to gain distinction as a brilliant lecturer; but Müller-Breslau achieved that distinction, and to those who could not spend part of their college time at Berlin he appealed through his books and varied papers. The fifth edition of the second part of his Graphic Statics of Building Construction appeared in 1922; his "Recent Methods of Stress Investigation" came out in its fifth edition in 1924; his last contribution to the Prussian Academy of Sciences, of which he had been a member since 1901, "Experiments on the Bending and Crippling Stresses in Aircraft," was presented in 1924. The special stress problems of aircraft had interested him from the early days of Count Zeppelin's experiments, in which he took an active part. He remained in intimate touch with practical problems through his own ramified work as a consulting engineer. He was twice Rector of the Charlottenburg Technical High School, which made him an honorary doctor on the occasion of his seventieth birthday; he had represented the technical High Schools in the Upper House of the Prussian Parliament since 1913, and also held the somewhat unusual honour of being an honorary member of the Technical High Schools of Breslau and Darmstadt.

THE DESIGN OF DOMESTIC GRATES.

THE observations of commercial grates that have been published from time to time have laboured under the disadvantage that the grates compared have usually differed from each other in more than one respect, and it has not been possible to say with certainty whether and to what extent the effect of one difference has been masked by that of another. In the series of investigations that Dr. Margaret White Fishenden carried out for the Manchester Air Pollution Advisory Committee, some experiments were made in which the structural details of the grates compared were varied one at a time, and the Fuel Research Board, which has now taken over the inquiry, has just published, with the concurrence of the Manchester Board, an account of some of these experiments.* As a fact the description of the experiments in question forms something under half of the report, part of the remainder being occupied by a brief and interesting summary of the history of the subject, and a statement of general considerations affecting the design and use of grates.

Since the time of Rumford, it has been recognised that the heating power of an open grate depends almost entirely on radiation, and not long afterwards Péclet, on the basis of experiments of his own, estimated that a coal fire in a round wire basket gave out by radiation some 50 per cent. of the total heat in the coal, and in the open grates of his time some 12 per cent. Of late years a good deal of experiment has been conducted with the object of determining the heat actually radiated from a fire, and the method adopted by Dr. Fishenden was that introduced by Mr. E. W. Smith in some experiments conducted at the University of Leeds, and used by Dr. Fishenden in subsequent observations, on which reports have already been published.† To apply it a special form of "radiometer"—a form of calorimeter with rectangular brass sides, one of which is corrugated and lamp-blacked—is placed with its blacked face opposite the centre of the fire at a distance from it of 34·4 in., and measures in absolute units the quantity of radiant energy falling on the lamp-blacked area. By means of a galvanometer and thermopile separate determinations are made of the relative intensities of the radiation at a large number of points on an imaginary hemisphere of 34·4 in. radius or 108 in. semi-circumference, with its centre at the centre of the fire. The points are, in fact, the 81 intersections of lines of "latitude" and "longitude" dividing the hemisphere at equal intervals, and by correcting for the variations of area of the sections so formed with the latitude, the ratio of the total radiation, as measured by the help of the thermopile-galvanometer readings, to the central reading can be calculated. The radiometer reading, expressing the radiation falling on the central area, is then multiplied by this ratio, which is termed the distribution factor, the product being the heat equivalent of the total radiation into the room; and this quantity, expressed as a percentage of the total calorific value of the fuel consumed, is the "radiation efficiency" of the fire. Even this circumstantial set of observations had to be further corrected for the variation with the state of the fire of the ratio of the thermopile readings at various points to that of the centre reading. This correction was made possible by the fact that no systematic variation of the thermopile readings with time was found along individual "parallels of latitude," and the mean distribution along each parallel having been determined, thermopile readings at the centre of each parallel taken repeatedly during the entire run enabled the necessary correction to be made, and when combined with the distributions along the parallels permitted the average distribution factors to be calculated.

Most of the present observations were made on a special experimental grate 15 in. wide, with twelve $\frac{5}{16}$-in. vertical iron bars 11 in. high in front, and a rectangular iron grid as bed, which was originally 12 in. deep from front to back, but was afterwards built up to depths of 7½ in. and 3½ in. The bed was about 11 in. from the hearth, and air for combustion appears to have been admitted below the bed through an otherwise tight-fitting fender, though this is not very clear. In these experiments the back of the grate was flat, being in the original form continuous with the back of the chimney and in the narrower grates extending to within a few inches below the chimney mouth; in the 3½-in. form this presumably had a marked effect on the draught. The fires were in each instance made about level with the top of the grate, and renewed at two intervals of 2 hours each, then being allowed to burn out. For each form of the grate a number of separate runs were made. The net outcome of the measurements,

* Technical Paper No. 13. "The Domestic Grate. An Experimental Investigation of the Relation between the Design of a Grate and the Heat Radiated into a Room." H.M. Stationary Office. 9*d.* net.

† Fuel Research Board. Special Report No. 3, 1920. The Coal Fire. Technical Paper No. 3. The Heating of Rooms.

details of which are given, was to show that the mean radiation efficiency of the full-sized grate was 12·4 per cent. of the theoretical heat of the coal—about the same as Péclet's—of the 7½-in. fire 15·7 per cent., and of the 3½-in. fire 21·9 per cent. The percentages plotted as ordinates against the depths of the fires lie on an easy curve rising steadily rather faster than the depth of the grate is reduced. As some sort of check on the apparent variation of the radiation efficiency inversely with the depth of the fire from front to back, an ordinary small, vertical-fronted grate was tested, the bed of which was a metal grid only 6 in. deep from front to back, with 12 light vertical bars along its front, which sloped from 15 in. at the front to about 11 in. at the back. The grid was 6 in. above the hearth, and the space beneath it was closed in by a fender, with an inlet through which air could enter and pass into the fire through a grid in a firebrick slab beneath the fire bed. The fires in this grate were lighted with 5 lb. of coal and fed every 2 hours with 4 lb. For subsequent runs—the report does not say whether the runs were repeated in each state of the grate—the grate was filled in with fireclay so as to give it a curved back about 4 in. deep at the back by about 1 in. at the sides. It was lighted with 5 lb. of coal, and fed every 2 hours with 2 lb. Apparently the height of the fire in this form must, at least on starting, have been much greater than in the original form of this grate; how this height compared with that of the fire in the experimental grate in any of its forms is not stated, nor is any comparison made between the two types of grate as to the relative draughts in through the fire and up the chimney or the completeness of combustion. Taking, however, the gross radiation efficiencies, without such correction, if any, as these factors would require for an exact comparison, that of the unaltered grate was found to be 18·2 per cent., and of the altered form, with 4 in. depth from front to back, 21·8 per cent. These percentages correspond on the curve derived from the three forms of the experimental grate to rectangular grates of that type with 5·8 in. and 3·8 in. depth from front to back respectively; from which the inference is drawn that the depth of a grate from front to back is an essential factor of its radiation efficiency.

Other runs were made on the experimental grate. Brought back to its original shape and size, its back was tilted forward at an angle of 45 deg. from a height of 9 in. above the fire bed, which appears to have given a chimney opening of about the same size as with the straight-backed 3½-in. form. This form of grate was also tried separately with the fire-bars removed. Another variant was to slope the sides of the full-sized grate with straight back from a few inches behind the front bars to a width of 4 in. at the back. The full-size grate with sloping back was lighted and fed with the same quantities of coal as in the straight-back experiments; particulars are not given of the coal used in the other two variants. The radiation efficiency with the sloping back was 16·8 per cent., against the 12·4 per cent. of the straight back; with the removal of the bars it increased to 17·4 per cent. The slanting sides increased the efficiency only to 12·7 per cent.

In the remainder of the report the author discusses the conditions in which coal fires are used and makes certain recommendations, including the suggestion of insulating the walls so as to retain as much as possible of the considerable proportion of the heat of combustion that falls on them. She regards 30 per cent. to 35 per cent. as the probable limit of radiation efficiency from fires against a wall, quoting Péclet's figure of 50 per cent. for the total radiation from coal fires in a round wire basket. The investigation appears to be in progress, and doubtless further work will clear up the points to which attention is drawn above as being left uncertain.

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this Society was held on Wednesday, May 20. The following papers were read and discussed:—

"*Further Remarks on the Meteorological Conditions of the Pleistocene Epoch.*" By the late F. W. Harmer, F.G.S., and C. E. P. Brooks, M.Sc.

The chief difference between the North Atlantic and North Pacific Oceans is that the former is open to the north, while the latter is practically closed to the north, since Bering Strait is too narrow and shallow to allow the passage of an appreciable current. Hence, in the Atlantic, the Gulf Stream travels north-eastward into the Arctic Ocean, while in the Pacific the Japan current is forced to turn south-eastward along the coast of America. This difference causes differences in the pressure distribution; both oceanic and atmospheric circulation combine to give western Europe a more genial climate than the west of North America. From this comparison it is concluded that the closing of the Greenland-Europe channel would bring about changes in the oceanic and atmospheric circulations which would suffice to cause a glacial epoch in Europe. The diversion of the storm tracks and the consequent alteration in the direction of the prevalent winds are probably even more important than the changes in the currents. The second part of the paper deals with the climatic changes in the Mediterranean region during the glacial period, and it is argued that the crowding together of the isotherms in southern Europe caused a great increase of storminess there, to which was due the torrential rains of which we have evidence.

"*On Fluid Motions Produced by Differences of Temperature and Humidity.*" By Harold Jeffreys, F.R.S.

It has been shown that the maintenance of a difference of temperature between parts of the same level surface in a fluid will necessarily maintain a permanent motion of the fluid, and that heating or cooling a fluid at an internal boundary will also maintain a permanent movement, however these boundaries may be situated. A corresponding theorem is true for the supply of new constituents instead of heat. This result appears to contradict a theorem given by Sandstrom and Bjerknes, to the effect that a permanent motion is possible only if the place where the heat is supplied is at a lower level than that where it is removed; but the arguments of these authors involve an unstated assumption, which seems to be untrue. If this assumption is not made, their argument leads to the result that the fluid moving from the lower temperature to the higher is at a lower level than that moving towards the colder regions. These inferences have been verified by working out fully a special case of the motion of a fluid in a closed pipe, heated on one side and cooled on the other. Sandstrom's experiment, in which no motion was observed in a tank under conditions suited to the production of a circulation, is found to be capable of a dynamical explanation based on the slowness of conduction and the consequent confinement of the currents to narrow regions where they would be very difficult to observe. It appears unlikely that it will often be possible to proceed by analogy from this experiment to the dynamics of wind, for radiation and turbulence will always redistribute the heat in such a way as to produce general currents; but there may be some applications to ocean currents.

"*Gustiness of Wind in Particular Cases.*" By A. H. R. Goldie, M.A.

The author attempts to classify wind eddies passing over the sea and deals particularly with examples from the anemograph records of Falmouth Observatory during periods of S.W. wind. It was found that the time interval of the rise and fall of the anemograph pen and of the breaking of the waves on the shore approximated to seven seconds. A further investigation, carried out at Lerwick, was an attempt to ascertain the normal relation between "range of gusts" and "hourly mean wind," in the case of equatorial currents. The ratio appears to be about one-third and nearly independent of velocity.

BOOKS RECEIVED.

French-English and English-French Dictionary of Technical Terms and Phrases used in Civil, Mechanical, Electrical, Mining Engineering and Allied Sciences. By J. O. KETTERIDGE. London: George Routledge and Sons, Limited. [Price 50*s.* net.]

Highway Engineers' Year Book, 1925. Edited by H. GILBERT WHYATT. Second edition. London: Sir Isaac Pitman and Sons, Limited. [Price 6*s.* net.]

United States Public Health Service. Public Health Bulletin No. 146. *A Study of the Pollution and Natural Purification of the Ohio River. III. Factors concerned in the Phenomena of Oxidation and Reaeration.* By H. W. STREETER and E. B. PHELPS. Washington: Government Printing Office. [Price 15 cents.]

Proceedings of the Institution of Railway Signal Engineers. Session, 1924-25. *Part II. August*, 1924, *to February*, 1925. Reading: Offices of the Institution. [Price 7*s.* 6*d.* to non-members.]

A Short History of American Railways. By SLASON THOMPSON. Chicago: Bureau of Railway News and Statistics. [Price 2 dollars.]

Theorie und Konstantenbestimmung des Hydrometrischen Flügels. By DR. ING. L. A. OTT. Berlin: Julius Springer. [Price 4.50 gold marks.]

Practical D.C. Armature Winding. By L. WOLLISON. London: Sir Isaac Pitman and Sons, Limited. [Price 7*s.* 6*d.* net.]

An Introduction to Fluid Motion. By W. W. BOND, B.A., B.Sc., D.Sc. London: Edward Arnold and Co. [Price 5*s.* net.]

Cours d'aviation destiné aux Elèves-Pilotes et Mécaniciens. By A. DESALEUX. Paris: Gauthier-Villars et Cie. [Price 35 francs.]

The Conversion of Coal into Oils. By Dr. FRANZ FISCHER. Authorised English Translation, Edited by R. LESSING, Ph.D., F.C.S. London: Ernest Benn, Limited. [Price 36*s.* net.]

Die graphische Statik. By R. LAUENSTEIN. Fifteenth edition. Leipzig: Alfred Kroner. [Price 6·50 marks.]

Die Eisenkonstruktionen des Hochbaues. Part I., Das Eisen und Seine Verbindungen. Part II., Eisen-und Deckenbau in Ausführung und Anwendung. By R. LAUENSTEIN. Leipzig: Alfred Kroner. [Price 5 marks each part.]

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Despite the fact that order books are in the main unsatisfactory, the holiday stoppage at representative works has not been of longer duration than usual. In face of the manifold difficulties under which they are labouring, manufacturers as a whole maintain the policy which they have steadfastly pursued during the recent period of depression of endeavouring to find employment for the largest possible number of men and boys, thus keeping them off the dole and Poor relief. This does not indicate, however, any change for the better in the general position affecting the iron, steel and engineering trades. Anxiety in the heavy sections is unrelieved. Sales have consistently shrunk since Christmas last, and there has been a correlative diminution in output of the principal manufactures of semi-materials. Scarcely any forward buying is reported in crude basic steel; inquiries for pig-iron are at a minimum consistent with the covering of immediate needs; while virtually the only business passing in iron and steel scrap is at prices which are distinctly favourable to buyers. Wrought-iron manufacturers are passing through a very trying period. Continental producers have succeeded in filching a large share of their trade, and, though British costs have been reduced to the lowest level consistent with economical output, the margin between home and foreign prices is still between 5*l.* and 6*l.* a ton. British makers are further hit by sales of cheap steel bars, which, on price considerations, are being put to a wider range of use. Acid-steel furnaces are able to carry on at something like 50 per cent. capacity, the demand being nearly twice as large as for basic steel, which can be delivered at works possessing their own furnace plant at lower rates than the bare cost of manufacture locally. The passenger-carrying services, as well as the motor and electrical trades, are furnishing a fair amount of orders on home account. Steady progress is reported in the utilisation of rust-resisting iron and steel for engineering purposes, outputs of these materials in some instances being double those of a year ago. Makers of certain classes of tools and of parts for agricultural machinery are probably doing better than any at the moment. Russian trade on the cash-with-order basis is steadily growing.

South Yorkshire Coal Trade.—Business is still greatly restricted by holiday influences. A fair number of orders have to be worked off, but the immediate outlook does not promise great activity. The demand for house coal of all qualities shows a big shrinkage owing to weather influences, and further price reductions are looked for. Restriction of outputs has had a steadying effect on steam-coal prices, but with weekly shipments not much more than half those for the corresponding period of last year, supplies are still abundant. Cobbles, nuts, and slacks remain fairly firm despite a disappointing scarcity of forward inquiries. Quotations:—Best branch hand-picked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 27*s.*; Derbyshire best brights, 24*s.* to 27*s.*; Derbyshire best house, 22*s.* to 24*s.*; Derbyshire best large nuts, 18*s.* to 22*s.*; Derbyshire best small nuts, 12*s.* to 14*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; smalls, 3*s.* 6*d.* to 5*s.* 6*d.*

COLOURED PENCILS.—A new type of coloured pencil, which is likely to be of service to engineers generally, has been introduced by Messrs. Alpco Pencils, Limited, of 173 and 175, Lower Clapton-road, London, E. 5. The new pencils differ from the more familiar form in the fact that they have thin leads which are made of material which permits of sharpening to a fine point. The pencils can be obtained in blue, red, green and yellow, and their special features should make them of considerable value in the drawing office.

ANNUAL REPORT OF APPRENTICESHIP ASSOCIATION.—The Nineteenth Annual Report of the Skilled Employment and Apprenticeship Association covering the year 1924 has now been published. The organisation has for its object the welfare and encouragement of young persons leaving school, and gives assistance, financial and otherwise, to those desirous of learning skilled trades, an especially important function at the present time, when the inducements to enter such occupations are small. During 1924 the Association dealt with 512 boys, placing 136 in the engineering and allied trades, 89 in clerical and similar work, 35 in instrument making, and the remainder in other trades. Boys and girls assisted together numbered 2,421. A good feature during the year reviewed in the Report was the extension, for the first time, of financial aid to affiliated committees.

PERSONAL.—It is announced by Vickers and International Combustion Engineering, Limited, of Africa House, Kingsway, London, W.C. 2, that the name of the company has been changed to International Combustion, Limited. The nominal capital of the company is being increased from 500,000*l.* to 1,200,000*l.* Sir Trevor Dawson, the chairman of the company, has resigned, and Mr. G. R. T. Gray, the managing director of the company, has been appointed chairman.—Mr. A. H. Besche, who for many years was sales director to Messrs. Kerr Stewart and Co., Limited, of London, has been appointed general sales manager to Messrs. J. and F. Howard, Limited, of Bedford.—Mr. W. A. Bristow, consulting aeronautical engineer, has removed to 39, Grosvenor-place, Westminster, London, S.W. 1, from 104, High Holborn, London, W.C. 1. Major Howard M. Whitley has been appointed by Mr. Bristow to take charge of the designing department of the Sumet Metal Corporation, Limited, located at the new address.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The limited production of Cleveland pig-iron is little indeed, if at all, in excess of current needs, and the stocks at makers' yards are understood to be small. The strong statistical position, however, fails to check fall in values. Though quotations are declared to be well under cost of output, buyers declare they experience little difficulty in shading reduced recognised market figures of 79*s.* 6*d.* for No. 1 quality; 74*s.* 6*d.* for No. 3 g.m.b., 73*s.* 6*d.* for No. 4 foundry, and 72*s.* 6*d.* for No. 4 forge.

Hematite.—East coast hematite makers have rather heavy accumulations at their works, and they are keen to negotiate. Home inquiries are of moderate dimensions, and export business is negligible. Nos. 1, 2 and 3 are obtainable at 80*s.*; and No. 1 is put at 6*d.* above mixed numbers.

Foreign Ore.—There is practically nothing doing in foreign ore. Sellers still base market rates on best rubio at 22*s.* c.i.f. Tees, but are prepared to accept lower terms.

Blast-furnace Coke.—Durham blast-furnace coke is in very ample supply and easy in price. Good medium qualities are quoted 21*s.* 6*d.* to 22*s.* delivered to local users.

Manufactured Iron and Steel.—Sales of manufactured iron and steel materials are not easily arranged. A few transactions in constructional steel and in railway requisites are reported, but in nearly all other branches business is extremely quiet. Common iron bars are 11*l.* 12*s.* 6*d.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.*; steel billets (medium), 8*l.* 15*s.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 8*l.* 10*s.*; steel angles, 8*l.* 5*s.*; steel joists, 8*l.* 5*s.*; heavy steel rails, 8*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 16*l.* 15*s.*

Shipments of Iron and Steel.—May shipments of iron and steel from the Tees totalled 72,294 tons, comprising 29,219 tons of pig-iron, 3,653 tons of manufactured iron, and 39,422 tons of steel. Of the pig-iron shipped, 13,510 tons went abroad and 15,709 tons went coastwise; of the manufactured iron cleared, 1,065 tons went overseas and 2,588 tons went coastwise; and of the steel loaded, 30,739 tons went to foreign ports and 8,683 tons went coastwise. As usual, Scotland was the largest buyer of pig-iron, receiving 15,169 tons; whilst Italy took 5,050 tons, Germany 1,680 tons, Belgium 1,503 tons, and America 1,260 tons. Natal, with an import of 480 tons, was the largest purchaser of manufactured iron. The principal importers of steel were: India, 8,358 tons; the Argentine Republic, 6,277 tons; Kenya, 3,117 tons; Australia, 1,895 tons; the Netherlands, 1,639 tons; and Natal, 1,424 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The state of affairs in the Scottish steel trade this week is no better. Producers have not been booking much business beyond the more immediate requirements of their customers, and in most instances these are exceedingly small. Conditions in the shipyards are gradually getting worse, and as general trade throughout the country is very poor the outlook for the steel makers is not bright. Inquiries from overseas are not good at present, and there are no signs of any improvement in that direction.

The makers of black sheets are being kept well employed, but poor prices are general owing to competition. Both home and export buyers are in the market, but the tonnage is not heavy. Galvanised sheets are keeping in good demand at firm prices, which have even a tendency to advance. The following are the market quotations:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 8*l.* 5*s.* per ton; sections, 8*l.* 5*s.* per ton; and sheets, $\frac{7}{16}$ in. to $\frac{1}{2}$ in., 10*l.* 5*s.* per ton; all delivered Glasgow stations.

Malleable-Iron Trade.—There has been no change in the condition of things in the malleable-iron trade of the West of Scotland this week. Makers are finding much difficulty in keeping their mills going as the day-to-day demand is very small. The prospects of any change for the better in the near future seem very poor. In the re-rolled steel branches improvement is very limited. The current price of "Crown" bars is unchanged at 11*l.* 12*s.* 6*d.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—Once again has it to be recorded that the demand for Scottish pig-iron, over the past week, has been very limited. Consumers, or at least buyers, are very few, either on home or export account. The result is that stocks continue to increase. Prices have eased off a bit, and the current quotations are as follows:—Hematite, 4*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 7*s.* 6*d.* per ton, and No. 3, 4*l.* 5*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending Saturday, May 30, was exceedingly small, and only amounted to 369 tons. Of that total only 4 tons went coastwise, and the balance of 365 tons went overseas. For the corresponding week of last year the figures were also small and consisted of 475 tons foreign and 224 tons coastwise, making a total shipment of 699 tons.

Shipbuilding.—The past month has not been a very great one in the shipbuilding industry when judging it from output or from new work placed. The tonnage launched during the three previous months was exceptionally good but a falling off took place in May, and the total was 20 vessels with a gross tonnage of 22,512. The following are the details from the different districts:—

	Vessels.	Tons.
The Clyde	16	22,002
The Forth	3	410
The Tay	—	—
The Dee and Moray Firth ...	1	100
Total	20	22,512

The Clyde figure is interesting from the fact that although the number of vessels launched is only eight less than during April the total tonnage is less than a fourth of that month. The year's output to date, now standing at 92 vessels of 259,506 tons, is only second to the record total of 1913, when the figures for the same period were 105 vessels of 293,997 tons. It is nevertheless a good way ahead of the figures for the corresponding five months of the past few years, but it is the future which gives some concern. The number of contracts on hand is very few—last month only some eight were reported—and the outlook gets more gloomy each month. Another new contract has just been intimated this week, the Clyde Trust having agreed to place an order with Messrs. William Simons and Co., Limited, Renfrew, for the construction of two steam hopper barges at a total cost of 70,750*l.* These vessels will each be of 1,200 tons capacity, and will be employed in the dredging of Dock No. 1, Shieldhall, the first of the new scheme, upon which work is now proceeding.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Owing to the intervention of the Whitsun holidays and suspension of work at the docks and the collieries, shipments of coal as foreign cargo in the past week amounted to only 330,440 tons, of which 189,110 tons were despatched from Cardiff, 59,480 tons from Newport, 55,780 tons from Swansea, 25,620 tons from Port Talbot and 450 tons from Llanelly. Of the total, 44,500 tons were sent to Algeria, 60,520 tons to France, 46,100 tons to Italy and 25,960 tons to Spain. Meanwhile the general inquiry was quiet, and in most cases prices displayed an easier tendency though salesmen still quoted recent figures. Buyers, however, were holding off with salesmen not disposed to commit themselves, preferring to await developments. Best Admiralty large coals ruled from 26*s.* to 26*s.* 3*d.* with Monmouthshires from 22*s.* 6*d.* to 24*s.* 6*d.*, and smalls from 12*s.* to 15*s.* Dry large coals remained quiet at 23*s.* 6*d.* to 25*s.* 6*d.* Unwashed dry duffs, however, were scarce and steady at 13*s.* 6*d.* to 14*s.*

Gould Fleet Sold.—Mr. David G. Hall, of Messrs. Hall, Lewis & Co., Cardiff, has purchased the eight steamers, totalling 62,000 tons deadweight, which formerly belonged to Gould Steamships and Industrials, Limited, for 300,000*l.*, or about 4*l.* 15*s.* per deadweight ton. Mr. Hall has appointed Mr. W. T. Gould to manage the fleet, which will still be controlled from Cardiff. The boats taken over are the Grelbank, Grelcaldy, Greldon, Greleden, Grelhead, Grelisle, Grelstone and Grelwen, all of which will be taken over on arrival in England, with the exception of the Grelbank, which is to be taken over at Bombay.

Iron and Steel.—Exports of iron and steel goods in the past week totalled 10,646 tons, compared with 12,301 tons in the previous week. Shipments of tinplates and terneplates amounted to 5,770 tons, compared with 7,921 tons, blackplates and sheets to 1,860 tons against 1,117 tons, galvanised sheets to 2,594 tons against 2,178 tons, and other iron and steel goods to 417 tons against 1,085 tons.

TESTS OF FIRE-RESISTING BITUMEN ROOFING.—The fire-resisting flexible asphalte roofing material known as "Pyropruf," and manufactured by Messrs. D. Anderson and Son, Limited, of London, Manchester and Belfast, was subjected to a fire test on April 23 at the London County Council Stores Depot, Pimlico, London. A previous demonstration of a similar nature, given on July 23, 1924, at Manchester, was referred to in our issue of August 1, on page 166. For the purpose of the recent trial a small brick building, divided into three sections, was erected, each section having a front door, back window and skylight. The outer sections were roofed with tiles and slates respectively, and the middle section with Pyropruf. All the compartments were partly filled with wood and other combustible material. The rafters were fire-proofed in order to hold up the roof as long as possible during the test. The first experiment demonstrated that the material could not be ignited from outside, and this was accomplished by setting the two outer sections on fire simultaneously. The conflagration was allowed to proceed for 15 minutes, and, although slates and tiles were falling in, the Pyropruf roofing remained intact. The contents of the middle compartment were then ignited, and shortly afterwards flames appeared through the skylight. Cold water poured on the hot roof at this juncture had no visible effect. For some 20 minutes the material kept the fire under control, until the rafters supporting the roof were burning freely. This was followed by the gradual carbonisation of the prepared bitumen. The test was a severe one; the temperature in the interior of the building, increased through the draught caused by the burnt-out door, window and skylight, reached a value estimated to be between 3,000 and 4,000 deg. F.

NOTICES OF MEETINGS.

THE FARADAY SOCIETY.—Monday, June 8, at 3.30 p.m., at the Institution of Civil Engineers, Great George-street, S.W. 1. Joint Meeting with the Iron and Steel Institute. "The Physical Chemistry of Steel-making Processes." Introductory Address by Sir Robert Hadfield, D.Met., F.R.S. "Balance Reactions in Steel Manufacture," by Dr. A. McCance. "Equilibria in Systems involving Ferrous Oxide," by Mr. J. B. Ferguson. "Slag Reactions," by Mr. P. MacNair. "A Study of the Reactions of the Basic Open-Hearth Furnace," by Mr. T. P. Colcough. "The Function of Ferric Oxide in the Acid and Basic Open-Hearth Processes," by Mr. J. H. Whiteley. "The Chemical Reactions in Basic Electric Process," by Mr. F. T. Sisco. "The Micro-examination of Steel-making Refractories," by Mr. W. J. Rees. "Physico-Chemical Phenomena from Melt to Ingot," by Mr. A. L. Field. Exhibition of apparatus by Messrs. Adam Hilger, Limited, John Griffin and Sons, Limited, and the Cambridge Instrument Company, Limited.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Monday, June 8, at 5 p.m., at Albemarle-street, W. 1. General Meeting. Friday, June 12, at 9 p.m. "Faraday as a Chemist," by Sir William Jackson Pope.

THE INSTITUTION OF GAS ENGINEERS.—Annual General Meeting, Tuesday, June 9, to Thursday, June 11, at the Institution of Civil Engineers, Great George-street, S.W. 1. Tuesday, June 9, at 10 a.m. Presidential Address. Report of Advisory Committee on Education, by Mr. F. W. Goodenough. Thirteenth Report of the Gas Investigation Committee: "Aeration in Atmospheric Burners, with Special Reference to Lighting Burners." Fourteenth Report of the Gas Investigation Committee: "Corbet Woodall Experimental Gas Plant Carbonisation Trials at the University, Leeds." At 3.15 p.m. "The Tankless Gasholder at the Etablissements Arbel, Douai, France," by M. L. Rolland d'Estape. "The Selection, Design and Construction of New Carbonising Plant at Stretford," by Mr. W. M. Carr. At 8 p.m. Reception and Dance at the Connaught Rooms, Great Queen-street, W.C. 2. Wednesday, June 10, at 10 a.m. Report of the Wrought-Iron Tubing Committee. Report of the Joint Refractories Research Committee. Report of the Sixth Meeting of the International Commission on Illumination. Report of the Institution Gas Research Fellowship on "The Influence of the Inorganic Constituents of Coal in Carbonisation and Gasification, with Special Reference to Nitrogen and Sulphur," by Mr. C. B. Marson, B.Sc., and Professor John W. Cobb, B.Sc., F.I.C. At 3.15 p.m. "Developments in Gas Calorimetry," by Professor C. V. Boys. Thursday, June 11, at 10 a.m. "Town's Gas for Motive Power," by Sir Dugald Clerk. "The Economics of Gas Production on the Thermal Basis," by Mr. George Evetts, M.Inst.C.E. At 2.30 p.m. Various Visits. Friday, June 12, at 8.45 a.m. Visit to Derby.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, June 9, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Discussion on "Natural and Artificial Sunlight in Health and Disease," by Dr. C. W. Saleeby.

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, June 10, at 6 p.m., at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C. Informal Meeting. Discussion on "The Application of the Supersonic Method of Reception to Ultra-Short Wave-Lengths," by Mr. W. K. Alford.

THE OPTICAL SOCIETY.—Thursday, June 11, at 7.30 p.m., at the Imperial College of Science and Technology, South Kensington, S.W. 7. "The Changes in the Form of the Crystalline Lens in Accommodation," by Mr. E. F. Fincham. "The Optical Properties of Amethyst Quartz," by Professor C. V. Raman, F.R.S., and Mr. K. Banerji. Exhibition of apparatus by Messrs. The Thermal Syndicate, Limited, and Dr. R. S. Clay.

THE ROYAL SOCIETY OF ARTS.—Friday, June 12, at 4.30 p.m., at John-street, Adelphi, W.C. 2. Indian Section. "The Heart of Asia and the Roof of the World," by Brigadier-General Sir Percy M. Sykes, K.C.I.E., C.M.G.

THE SCIENCE MUSEUM AT KENSINGTON.—We have received three booklets forming part of a catalogue of the collections in the Science Museum at South Kensington, London. The first volume, compiled by Mr. H. W. Dickinson, is entitled "Stationary Engines" and consists of explanatory notes, following numbers corresponding to exhibits in the museum, relating to the invention and development of the steam engine and other prime movers. An index and illustrations of old and new plant are included at the end of the book, copies of which may be obtained from H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2, at the price of 2*s.* net. The second publication in our possession is part two of that section of the catalogue dealing with "Land Transport," which has been prepared by Mr. E. A. Forward. This book deals with mechanical road vehicles and is consequently largely devoted to the history and development of the motor car and cycle as exemplified in models of the various equipment fitted at different periods. The third volume, part three of the section dealing with "Water Transport," describes Steam Ships of War and was written by Mr. G. L. Overton. In this contribution the growth of the modern steel naval unit is traced up to the present time. A large number of illustrations of models are supplied throughout the book. Ample explanations indicate the revolutionary changes in naval design typified by the "Dreadnoughts" of the first decade of the present century and the speedy battle cruisers laid down during the Great War. Each of the last two volumes is obtainable at a price of 1*s.* net.

LITTLETON RESERVOIR; OUTLET CONDUITS.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(*For Description, see Page* 690.)

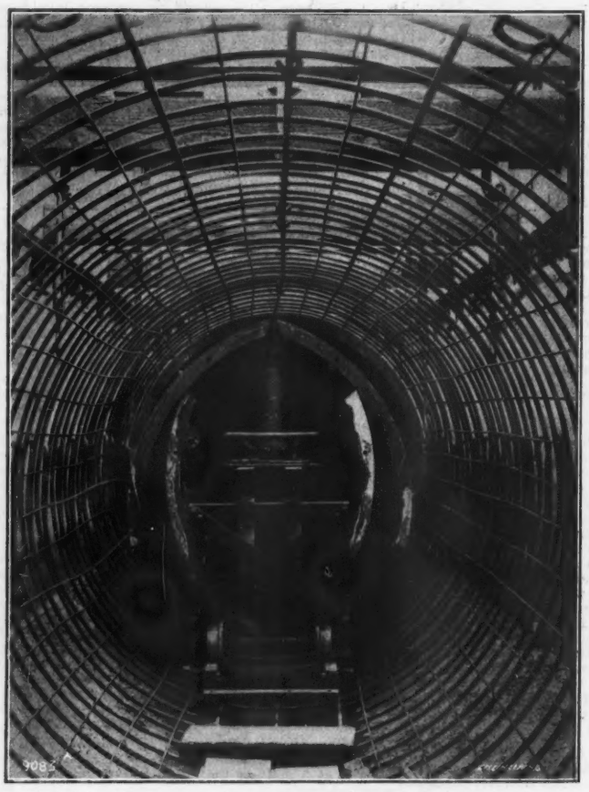


FIG. 67. COLLAPSIBLE STEEL CENTRING OF 6-FT. CONDUIT ON MOVABLE CARRIAGE.

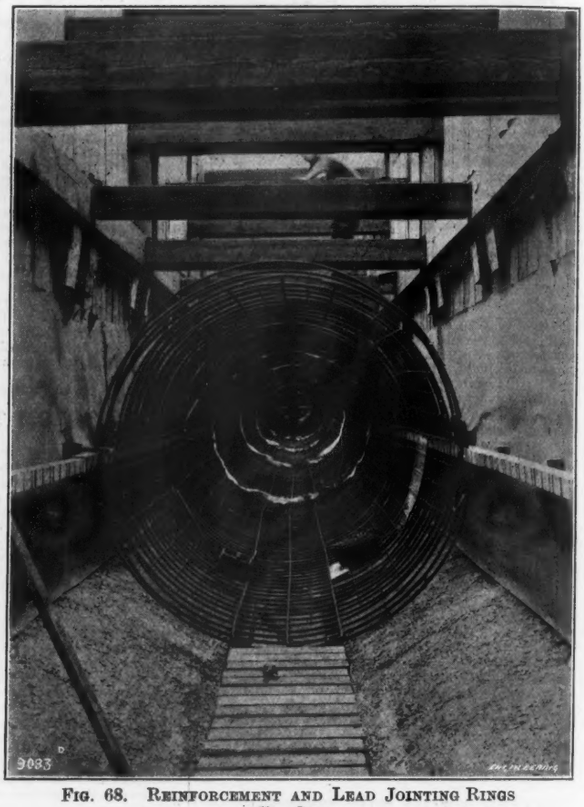


FIG. 68. REINFORCEMENT AND LEAD JOINTING RINGS FOR 6-FT. CONDUIT.

FIG. 69. 6-FT. CONDUIT SHOWING STEEL FORMS AND CAST-IRON BRANCH CONNECTION.

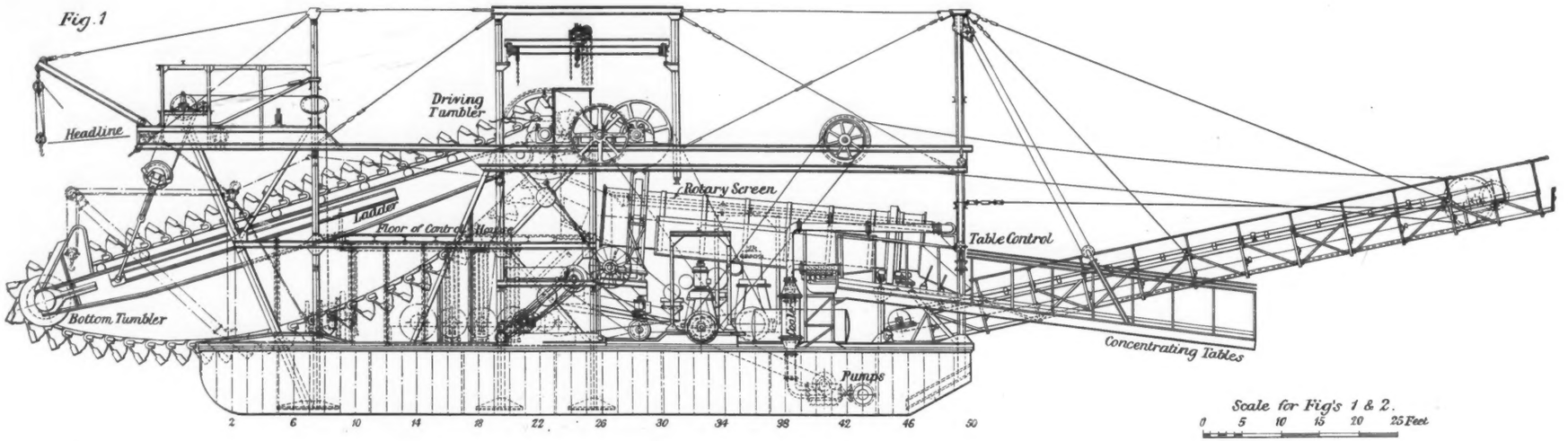
FIG. 70. REINFORCEMENT AND TIMBER CENTRING FOR CONNECTION OF 6-FT. CONDUIT TO 4-FT. CAST IRON MAIN.

BUCKET DREDGE FOR ALLUVIAL GOLD.

CONSTRUCTED TO THE DESIGNS OF MESSRS F W. PAYNE AND SON, CONSULTING ENGINEERS, LONDON.

(*For Description, see Page* 697.)

Fig. 1



Scale for Fig's 1 & 2.
0 5 10 15 20 25 Feet

Fig. 2.

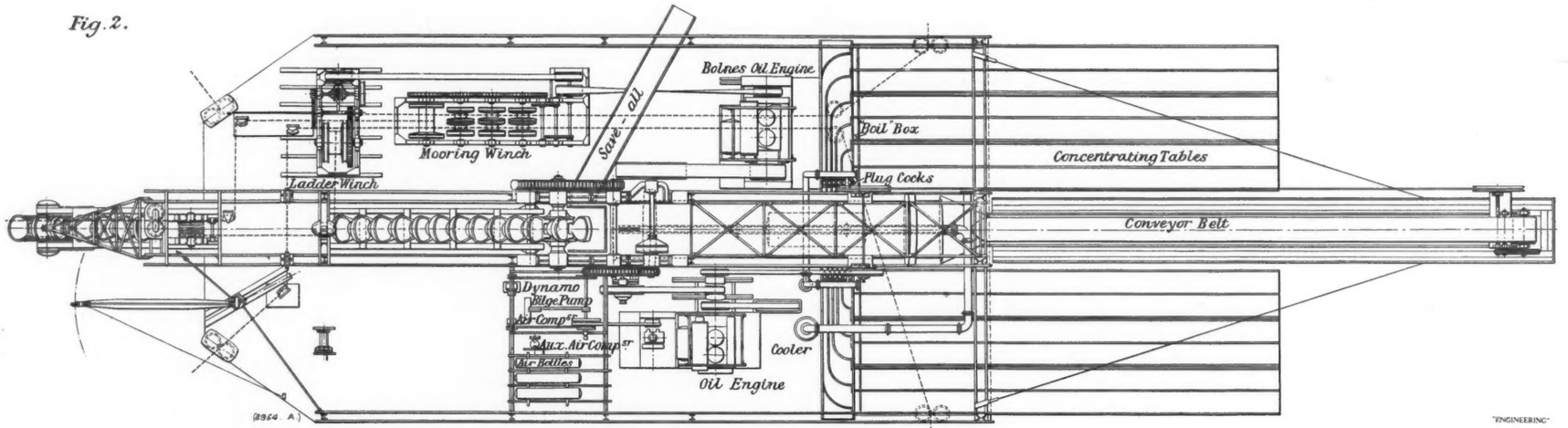


Fig. 3.

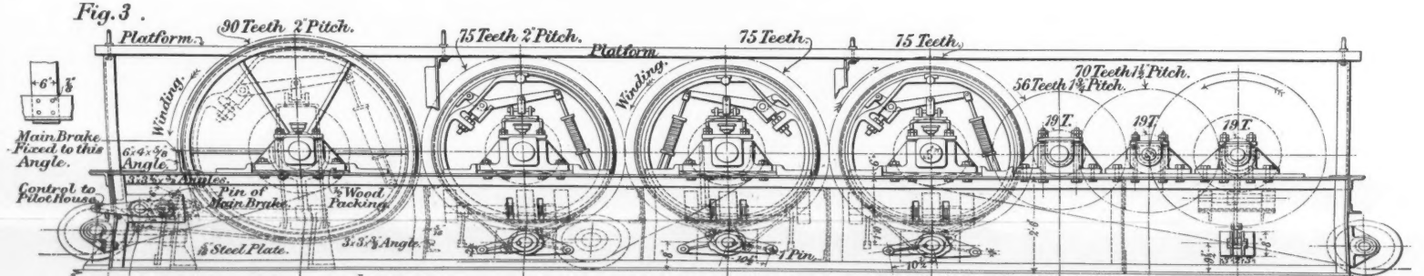
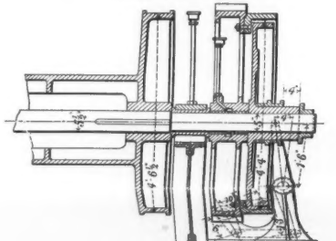


Fig. 6. CROSS SECTION OF HEAD LINE DRUM.



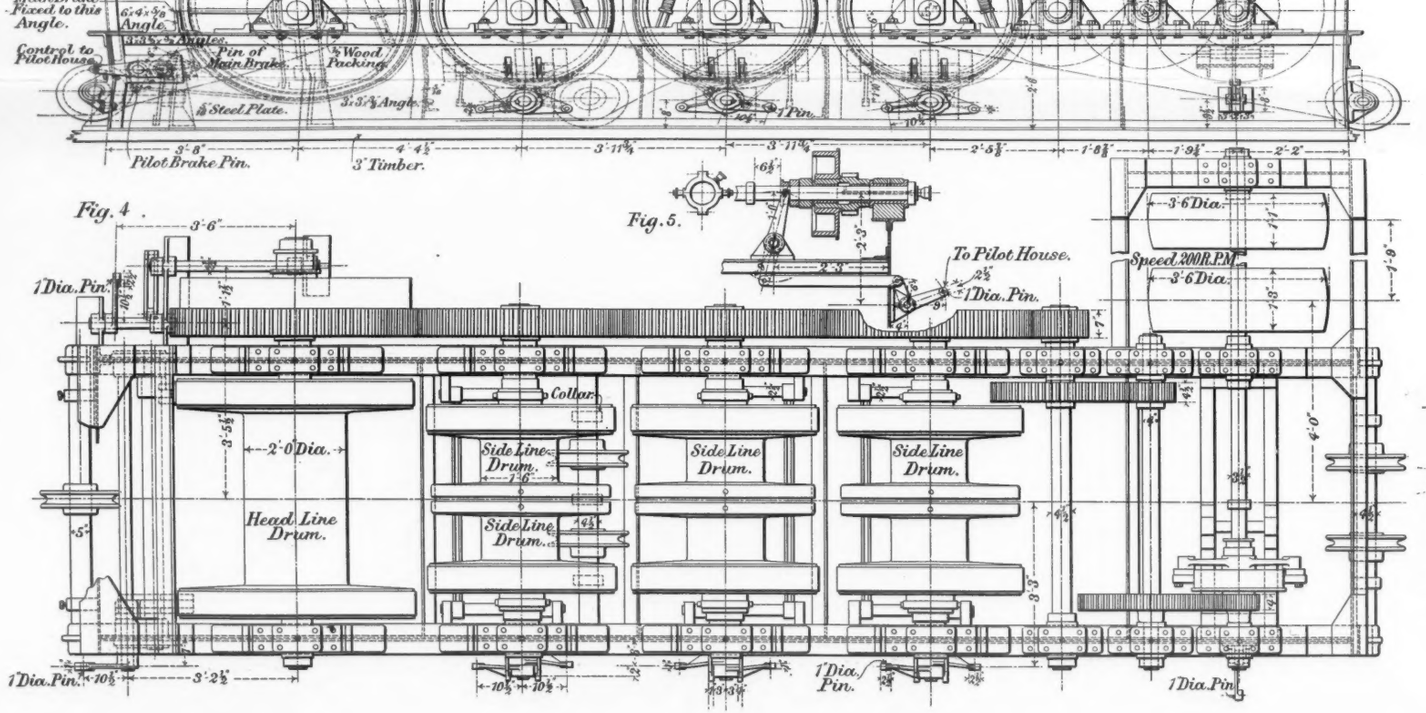


Fig. 4.
Fig. 5.
Fig. 7. CROSS SECTION OF SIDE LINE DRUM.
Pilot Brake Pin.
3" Timber.
Control to Pilot House.
Pin of Main Brake.
Wood Packing
Steel Plate.
To Pilot House.
Speed 200 R.P.M.
3'6 Dia.
Collar.
Side Line Drum.
Head Line Drum.
2'0 Dia.
Lubricators.
5'6" Centres of Frames.
(8964.B)
"ENGINEERING"

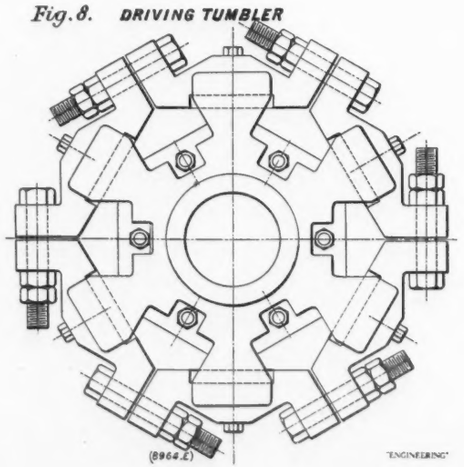


Fig. 8. DRIVING TUMBLER
(8964.E)
"ENGINEERING"

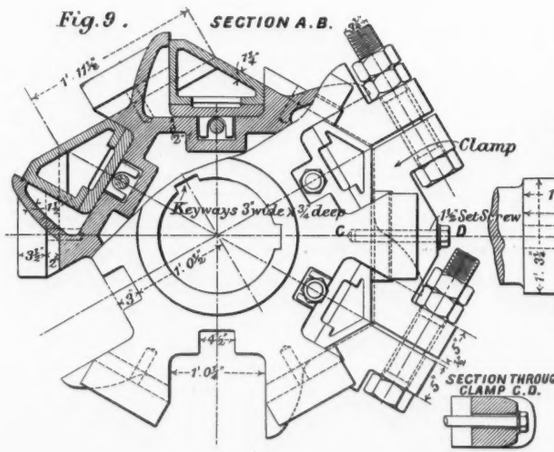


Fig. 9. SECTION A.B.
Clamp
Keyways 3" wide x 3/4" deep
1½" Set Screw
SECTION THROUGH CLAMP C.D.

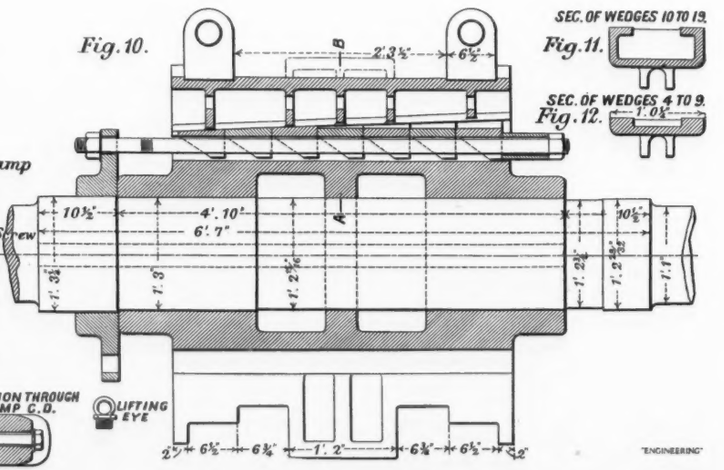


Fig. 10.
Fig. 11.
SEC. OF WEDGES 10 TO 13.
Fig. 12.
SEC. OF WEDGES 4 TO 9.
LIFTING EYE
"ENGINEERING"

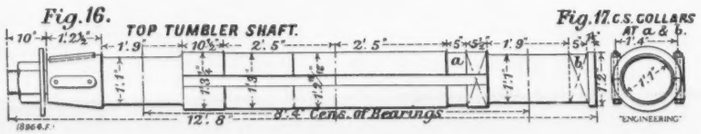


Fig. 16. TOP TUMBLER SHAFT.
Fig. 17. C.S. COLLARS AT a & b.
12'8" & 8'4" Cens. of Bearings
(8964.F)
"ENGINEERING"

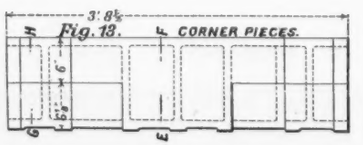


Fig. 13. CORNER PIECES.

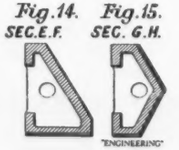


Fig. 14. SEC. E.F.
Fig. 15. SEC. G.H.
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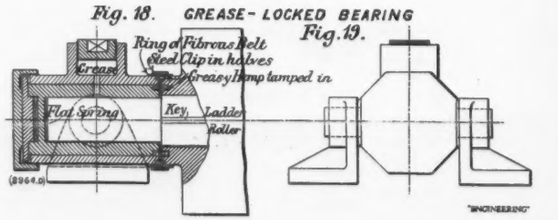
Fig. 18. GREASE-LOCKED BEARING
Fig. 19.
Ring of Fibrous Belt
Steel Clip in halves
Grease
Flat Spring
Key
Ladder Roller
(8964.D)
"ENGINEERING"

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ENGINEERING.

FRIDAY, JUNE 5, 1925.

THE INVESTIGATION OF INDUSTRIAL FATIGUE.

WHEN the reduction of industrial fatigue has been mentioned in some engineering circles, and these not the least eminent or experienced, it has come of late to be dismissed as an impossibility, "because the men do not or are not allowed to work hard enough to produce any fatigue at all." If that were a fair statement of an unalterable position, it would mark the beginning of an ignoble end to British engineering manufacture. No international industry can survive in competition with other countries if it uses any important raw material less efficiently than they. The end is still more certain when the wasted material is the largest element in prime costs, as wages are in most engineering trades; most certain of all when the industry is paying, and is out to pay, higher wages than are earned in the competing industries of other countries.

That there must be some foundation for the complaint is beyond question. It is made by persons who are in the best possible position to know what goes on in some important works. It is not bandied about in polemical discussions, but expresses the considered convictions of the speakers, which they exchange among each other without contradiction. That the statement is not true of all shops is equally certain, and there is no reason why it should remain true even in the shops on whose experience it is founded. But if it ceases to be true, the interest of all concerned in industry will require that the hard work shall be done with the least possible fatigue. Practically the only measure of fatigue that seems to be available is a reduced ability to do work, a state that both is unpleasant in itself, and decreases the value that the industry obtains for the energy spent. It is evident beyond question that such a condition is consistent with neither the desire to live comfortably nor the still more urgent need to make as sure as possible of the means of living at all. If methods are available for learning more of what causes the waste of energy that is summarised as fatigue and for devising means to avoid this waste, no subject can be better worth the attention of the industries in which such waste occurs.

The fifth Annual Report of the Industrial Fatigue Research Board* contains a clear summary of what the Board has done during last year. So much of its proceedings as has yet been published has already been noticed in these columns, and there is no need either to repeat what has been said or to describe the succinct and detailed particulars of work in hand and in contemplation that are given in the present report. A number of personal contributions from investigators are included in a second part, and deal with aspects of the work that are well worth consideration. But what appears to be the most immediately important fact contained in the report is disclosed in the weighty conclusion that follows on the story of the year's work. Last year the Board pointed out that the co-operation of the industries themselves was necessary to trying out some of the results of which its investigations had given *prima facie* evidence. To this end its fourth report suggested that each important industry should form a small committee, representative of employers and workmen, for the purpose of consulting with bodies like the Board and the National Institute of Industrial Psychology in regard to measures that affected "the human factor," and that the conclusions which appeared to deserve it should be tested finally in suitable factories. Up to the present the response made to these suggestions is said to have been disappointing, and even industries that have entertained them have as yet decided on no definite action.

The explanations suggested in the report for the apparent indifference of industries to the Board's work are that the industries are, and in recent years have constantly been, occupied with discussing matters which required immediate settlement; that they are oppressed by financial stringency, and fail to appreciate the real issues. No doubt can be felt that these influences have helped to the result the report deplores. It is easier, for example, to acquire the habit of discussion than to gratify it without injury to more active work. In one of the personal contributions Miss Ethel Newbold quotes from Sir James Frazer a primitive example, which shows among other things how some sorts of discussion arise: "Among the Gallas, when a woman grows tired of housekeeping she begins to talk incoherently and to demean herself extravagantly. This is a sign of the descent of the Holy Spirit Callo upon her. Immediately her husband prostrates himself and adores her, she ceases to bear the humble title of wife and is called 'Lord,' domestic duties have no further claim upon her, and her will is a divine law." Industrial leaders of trade unions have had to recognise the same sort of behaviour nearer home than the Gallas—wherever they may have existed—and must be aware that it has caused much of the discussion which has interfered with urgent trade interests. Until the position of trade unions is so regulated that their control lies with the industrial members and their influence cannot be assumed and imposed on the majority for non-industrial objects, such as the Holy Spirit Callo seems to have suggested to the Gallas ladies, the time and resources of industry will always be liable to be taxed by settlements and discussions. But although the explanations suggested by the Board are doubtless substantial as far as they go, they appear to omit the root of the matter. There are plenty of representative institutions in industry already without creating them artificially. Sensible employers and men in a works can and do readily find means of discussing their common and respective interests. For the time being progress is far more likely if employers and men in each works mind their own business, and do not seek to add to the mechanisms for interfering with the business of other works and for submitting to interference from them. It is

* H.M. Stationery Office. [1*s.* 9*d.* net.]

incredible that works could not be found in which the Board's results could be tried out, if the works thought that the results showed sufficient promise of practical value.

The most probable reason for the failure of industry to proceed with the work that some of the Board's results may suggest is that many of the results do not seem to industry as promising as they do to the Board. The physiology and psychology of fatigue is as yet imperfectly understood. A valuable part of the Board's work is addressed to improving such knowledge of fatigue as already exists, and a large number of tests emanating from the laboratories of those sciences are waiting a calibration by practical experience that must take considerable time. The co-operation of physiologists and psychologists in the application of such tests and in much other work necessary in investigating fatigue is the more necessary because of the present imperfection of the available data. On the other hand, any industry has complexities of its own, even less able to be expressed in general terms than those of the biological sciences. For a thorough investigation, the results of which are to be applied in the conditions of industry, the co-operation of men familiar at first hand with those conditions is as indispensable as that of adepts in the biological sciences. It is useless or worse to ask engineers to provide information and mechanism, and leave biologists to apply it. For the work to have practical value and to command the confidence of an engineering industry, an engineer familiar no less with the circumstances of the trade than with scientific methods must co-operate in planning and supervising it. With the possible exception of the enquiry into machine design no work seems yet to have been attempted under these conditions. So far as concerns the engineering trades, it is to be feared that until the Board associates an engineer of adequate practical and scientific experience with the planning and supervision of its work, it will not attract the confidence that it seeks and needs.

THE PRESENT POSITION OF THE BRITISH ELECTRICAL INDUSTRIES.

EVERYONE in the electrical industries must be familiar with the fact that the costs of production of electrical machinery and cables are much in excess of those of other countries and consequently the development of the application of electricity in the British Isles is hampered in a most distressing way. Though such knowledge may be general few are, perhaps, aware of the actual extent to which these troubles exist, or of the magnitude of the restrictions they impose on the development of industry and the increase of employment. We, therefore, welcome the statements, which have been prepared by Mr. D. N. Dunlop, the Director of the British Electrical and Allied Manufacturers' Association, and Mr. L. B. Atkinson, the Director of the Cable Makers' Association, for presentation to the Board of Trade Committee on Industry and Trade. Both of these authorities have the facilities for obtaining reliable statistics on the actual state of present-day trade and the figures, which they presented in their evidence before the Committee on Wednesday, May 27, are worthy of close attention by all who are making endeavours to understand what changes are necessary before the electrical trades can obtain a greater share in the world's markets.

Mr. Dunlop is quite convinced that the high cost of production is the most potent factor in reducing the competitive power of the industry, and that it was only because of the retention in British plant of the characteristics of the highest qualities of workmanship and design with the resulting exceptional efficiency that orders have been obtained. In explanation of the changed conditions operating in the industry, it was stated by Mr. Dunlop that wages have been doubled in the period from 1913 to 1923, local taxation has been increased by 220 per cent. and Imperial taxation by 680 per cent. Materials have risen in price between 60 and 70 per cent., and all these changes have had the total effect of increasing the costs of production by 83 per cent. Under such conditions it is, indeed, surprising that industry can be carried on at all, but it must be remembered that these were the conditions in 1923 and that in the following year there was a tendency for wages and materials to increase still further and thus magnify the difficulties of the manufacturers. In examining the wage position as far as it is affected by cost of living, it should be noted that the cost of living index on a gold basis in Britain stood in December, 1924, at 173·7, compared with 123·0 in Germany, 105·4 in France, 127·6 in Italy and 94·8 in Austria. The increase in taxation has already been referred to in regard to its percentage increase, but it is necessary if a true estimate of the position of the electrical industry is to be made, to consider what addition it means to the sum total of overhead expenditure. Prior to the War taxation only represented 1·5 per cent. of the value of the output of the industry, whereas in 1923 when the output was 113 per cent. greater it amounted to 4·7 per cent. These figures are very significant. If expansion of industry must be made, if the workmen of this country are to be provided with the blessing of employment there must be a reserve left to the manufacturers to meet the depreciation of their capital and to be available for new investment in extensions. At the present time the profit margin which is necessary for these purposes is reduced to the vanishing point and mainly goes to meet the ever-enlarging requirements of the national and municipal services. Mr. Dunlop stated to the Committee that he thought industry bore too large a proportion of the taxation of the country and that a more equitable distribution of the incidence of taxation was the first essential to the restoration of industrial prosperity. This is, no doubt, true, but there can also be no question that the country is much over-taxed as a whole. Mr. Edgar Crammond in a lecture on "The Economic Position of Great Britain" to the Institution of Civil Engineers, in October of last year reviewed the relationship between the various items in the national income and expenditure for the years 1907 and 1923, and showed that the cost of the national services increased from 8·5 per cent. of the national income in 1907 to 19·4 per cent. in 1923. While this took place the percentage of the national income which was available to meet depreciation of capital and for new investment at home and abroad was reduced from 23·7 to 9·7. Under such conditions it was quite fair comment on the part of Mr. Crammond to say that "we were in danger of becoming a nation of rentiers and civil servants instead of a nation of merchant venturers."

The accelerated development of electrical enterprises is essential to the national well-being. Power must be supplied at low rates to industry if it is to compete in the markets of the world. France is adding to her electrical generating plant at the rate of 700,000 kw. every year, while we can only effect an increase of a much smaller value, namely, 450,000 kw. What is the position regarding the increase of output of the factories producing electrical machinery may be judged from Mr. Dunlop's statement that while the output of the United States factories had increased 200 per cent. between 1914 and 1924, the corresponding figure for France being 190 per cent., Britain could only show an improvement to the extent of 113 per cent. Not merely was the development slow in Britain in this period, but at the time taken as the starting point for this investigation, production in the British factories was small compared with those of other countries, and consequently the position was all the more unsatisfactory. Had there been the same relative development in Britain as in the United States, the electrical industry could have found employment for more than twice the number of workers actually engaged, and so could have contributed in no small measure to the solution of the unemployment problem.

The British insulated electric cable industry has a total production for home use and export, after allowing for the different level of prices, of about twice that existing before the European War. Competition from abroad, both in this country and in the export markets, is very severe and the margin of profits has had to be greatly cut down. The very conservative financial policy, said Mr. Atkinson in his evidence before the Committee, had resulted in considerable amounts of capital having been invested in the principal cable companies at very low rates of interest, and this, coupled with the small share capitals of the companies, accounted for the apparently high dividends which were paid on that small share capital. The actual return measured over the whole capital was, however, comparatively small. Overseas trade was difficult to maintain, particularly in the Dominions, as efforts were being made to start production in many of our former markets, and heavy tariffs were being imposed with a view to the fostering of the industry. In this, as in many other trades which have to obtain their raw materials abroad at prices the same as those obtained from their competitors abroad, wages are an important factor in determining the amount of business done. As the rates of wages in Continental countries which produce cables are considerably lower, and the overhead charges due to rates and taxes are also much less, the total cost of production is such as makes competition almost impossible by the British concerns and, in consequence, large orders had been placed abroad recently by various supply companies and municipalities.

GLASSES AS UNDERCOOLED LIQUIDS.

PLINY ascribed the discovery of glass to the Phœnicians. He was himself doubtful, and the accidental discovery that sea sand and potash would give a glass when fused together may have been made several times before and after the Phœnicians. But there certainly was a glass industry in ancient Phœnicia by 1800 B.C., and earlier probably, in Egypt. Since then many new glasses have been invented, and every branch of modern science owes much to these new glasses. Thanks also to this development physicists are now rather more, than less, guarded in replying to any inquiries as to the constitution of glass. The Society of Glass Technology devoted its May meeting to the discussion of this problem. This was opened by Professor W. E. S. Turner who had critically examined the recent researches of the most diverse character and had come to the conclusion that, though the molecules in glasses are certainly complex, we have no proof of the existence of definite compounds in glass, and that our knowledge of the fundamental data concerning the glassy condition is unsatisfactory. With this, Professor Tammann, of Göttingen, who had sent in a paper in which glasses were considered as undercooled liquids, would not have dissented.

The view that glasses are undercooled liquids was advocated by Tammann thirty years ago and is, of course, widely held now. Glass is in a condition intermediate between the solid and liquid states. At ordinary temperature that condition may, as Messrs. Tool and Hill, of the Bureau of Standards, put it in another paper, be regarded as undercooled with respect, not only to the crystallisation or true solidification, but also to many processes normal to the vitreous condition. When a crystal is heated, it begins in general to melt at a definite temperature; only crystals which form very slowly can be superheated. But on cooling, most crystals behave differently. The melt can be undercooled before crystallisation will begin, and the crystallisation may set in at certain centres, or crystals may grow in all directions from one centre as in a spherulite. Crystallisation and the capacity for undercooling depend, according to Tammann, upon the number of crystallisation centres (nucleus number) formed in unit volume per unit of time, and upon the linear rate of growth of the crystals in the undercooled liquid. Fusing some of his substances in sealed glass tubes, he found that, for easily fusible substances the maximum nucleus number was attained after undercooling by about 100 deg. C., and that in other cases no centres whatever originated even with strong undercooling. The rate of growth of the crystals increased with the degree of cooling and with the ease with which the latent heat of crystallisation could escape; for a crystal growth of about 4 mm. per minute the rate of crystallisation

had its maximum when the undercooling amounted to about 20 deg. The viscosity changes at first very little with undercooling. Most liquids (except fused silica, acid aluminium silicates and arsenic acid) remain mobile until undercooled by about 90 deg.; then the viscosity increases rapidly, and when undercooled by 110 deg. C. glasses turn hard and brittle. Vitreous substances have no definite melting point, and there is no distinct absorption of heat during their gradual softening. To obtain a good amorphous glass, the rate of undercooling should be especially rapid in the undercooling range of 30 to 100 deg. The smaller the mass of liquid, the more rapidly it will turn into a glass by sudden cooling, since the nucleus number is small in a small volume.

The stability of the liquid and solid phases depends upon the vapour pressure curves of the liquid and of the crystal and on the fusion curve of the crystal; for the vitreous condition equilibrium diagrams can hardly be drawn. The temperature at which the glass softens increases with rising pressure; below that temperature line the glass is unstable; it can only become stable at a high pressure, and it appears stable only because no crystallisation centre can form at that particular temperature, or because any crystal growth is too slow for observation. Of the homogeneous vitreous substances, boric anhydride is the only one which has never been observed to crystallise, and which appears to be stable at ordinary temperature and pressure. For the study of devitrification Tammann heated long rods of glass in electric furnaces so wound that the temperature gradient along the rod amounted to several hundred degrees. On the temperature curve observed the maxima mentioned (of nucleus number and of rate of crystallisation) can be traced and the melting point of the devitrification product be estimated. Sodium silicate, vitrified by rapid chilling, shows a kind of recalescence (spontaneous heating) when slowly reheated, first at 550 deg. and then again at 800 deg., and devitrification begins about 500 deg. below the melting point of the crystal, 1,055 deg. Tammann converted 59 of 153 easily-fusible substances into glasses by sudden chilling, and more drastic chilling increased that proportion.

Thus the glassy state is not an exceptional condition. Metals have not yet been obtained in the vitreous state. Of the other chemical elements, sulphur, selenium and even oxygen have, however, been observed in that state (oxygen by Wahl). Of the oxides, the acids B_2O_3, As_2O_3, P_2O_5, SiO_2 readily form glasses, and their salts do so the more easily the more the acid predominates; metaphosphoric and pyrosulphuric acids also yield glassy potassium salts. The sulphides of arsenic and antimony have been prepared in the condition of glass; hydrated calcium chloride and ferric chloride form glasses, and vitreous enclosures are frequent in volcanic rocks.

We have to revert to several of the points mentioned. The nucleus number is mostly—though not in the case of metals—exceedingly small, compared to the number of molecules. Crystallisation seems to require the similar orientation of at least eight neighbouring molecules; X-ray analysis may help us to understand the nature of the directive forces which play so important a part in the optical characteristics, face development, strength, and general properties of crystals in preferential directions. Though subject, apparently, to the law of probability, the nucleus number is very variable. It is not always the same even for the same temperature on an ascending or a falling temperature curve and it is affected by mere remelting; that may explain the fact mentioned by Mr. Coad-Pryor during the discussion, that samples may physically differ from the products they are supposed to represent, though of the same chemical composition. These features have largely to be studied at moderate temperatures. In the case of lauric acid (melting point, 43·2 deg. C.), which has a relatively large nucleus number, the appearance of the first nucleus in a melt of one gramme took 2·5 seconds, with an undercooling of 3·2 deg.; 10 seconds with 1·2 deg. undercooling; and 1,200 seconds with an undercooling of 0·4 deg.

The viscosity, as stated, changes rapidly during the solidifying stage. According to H. Le Chatelier $\log \eta = P - M t$, where η indicates viscosity, t temperature and P and M are constants. The constant M is small for substances whose solidifying range lies at high temperatures. For soda-lime-silica glass (range 500 to 900 deg.), S. English found last year $M = 0{\cdot}0011$, for betol (range 15 to 50 deg.), $M = 0{\cdot}0158$. The range should be large and the M be small to facilitate the blowing, spinning and working of the glass; but if the maximum nucleus number falls within that range, glass working becomes very difficult. Chemically-homogeneous substances rarely have a high undercooling capacity and generally tend to devitrify when prepared in large masses. The presence of foreign substances in quantity prevents the formation of crystallisation centres, unless they throw out mixed crystals. When in binary metallic mixtures both components crystallise without significant undercooling, the eutectic also crystallises without undercooling. Bismuth and antimony crystallise with slight undercooling; in their alloys with other metals the crystallisation of the eutectic starts with the same degree of undercooling as the bismuth or the antimony. Professor Tammann considers it probable that in the metals the nucleus numbers are too great to make small diminutions noticeable.

The silicates, borates, and phosphates included in glasses offer more complex problems. Neither component may itself require undercooling to start crystallisation, or one or both may do. Mixtures of the silicates of magnesium and sodium, and also of lithium and zinc, solidify as glasses; mixtures of the silicates of potassium and lithium solidify partly as glass, but tend also to crystallise; mixtures of sodium metaborate and metaphosphate solidify as glass, though either salt crystallises readily. The ordinary soda-lime-silica glasses are ternary mixtures, the sodium and calcium silicates of which readily crystallise alone and in mixtures; when an excess of 8 per cent. of silica is present, the mixtures solidify as glasses. Only systematic researches on glass batches can throw light on these questions.

BRITISH AND AMERICAN PRACTICE IN STRUCTURAL STEEL DESIGN.

By ROBINS FLEMING, New York City.

IT is the purpose of this article to review British and American practice in structural engineering from an American standpoint. In such a review the literature on the subject takes first place, and of the literature the textbook stands out prominently. The British textbook author has a fondness for mathematics and, while not neglecting the graphical, prefers analytical methods in obtaining stresses in framed structures. The American textbook author, while not neglecting mathematical, makes considerable use of graphical methods. Solutions by "influence lines" are more or less prominent in American textbooks. Much attention is given to what is commonly called the "practical" side of engineering. Such books as Johnson, Bryan and Turneaure's "Modern Framed Structures" and Ketchum's "Steel Mill Buildings" give a wealth of detail and illustration in the actual practice of designing.

A weakness in both American and British textbooks is that many of the details and designs given are not up to date. This is hardly the fault of the authors. Fabricating firms are reluctant to give out for publication their latest ideas. Moreover, it may be two or three years from the time the author receives whatever material is given him until it appears in his book. After a book is issued it is expensive to make changes in plates for subsequent editions. The result is that the student may be studying designs and methods in use ten or twenty years previously, and which have in the interval given place to others. Recourse must, therefore, be had to the periodical press for the latest designs.

The scholarship shown in the textbooks of both countries is of a high order. What may be called "lapses" occur but rarely. For instance, both Spofford (American,) "The Theory of Structures," and Morley (British), "Theory of Structures," find compressive stresses due to the shortening of the column in the lattice bars of a double 15-in. channel column, latticed on each side with a system of single lacing. These stresses are additional to those due to lateral deflection. The practical results of these findings, if correct, would increase the stresses in lattice bars over those determined by present methods. But can such compressive stresses exist? If they did, the column ribs would bow out at panel points, producing a distortion of both lattice bars and ribs. The lattice systems considered by Spofford and Morley should not be confused with a system of double lacing with cross ties at the panel points (such as was used in the first Quebec Bridge), in which the diagonals are forced to take part of the compressive stress in the column, because the ribs are kept the same distance apart by the cross ties.

The handbooks issued by British steel manufacturers have not, in the past, been as encyclopædic in their contents as the Carnegie "Pocket Companion" or the Cambria "Steel." Some engineers may say that such handbooks are not needed, that they breed what may be called the "handbook engineer." However, such books are at times very convenient; naturally, the user of a handbook should be its master and not its slave. A change is taking place in British handbooks. That of Dorman, Long and Co., Limited, of 1924, is similar to the Carnegie book in size and appearance. Its 400 pages are filled with information useful to the designing engineer. The 300 pages of Arrol's "Bridge and Structural Engineer's Handbook" contain many bits of information not found in textbooks.

A score of titles could be quoted indicating the scholarly note of many of the articles in British technical journals. A feature of one, "Half Hours in a Library," giving a brief mention of articles in other papers, could well be introduced in the United States. American engineering periodicals have their own distinctive features. Reviews of important books are usually written and signed by an authority on the subject of which they treat. Especial attention is given to failures of structures; the collapse of a highway bridge or the fall of a building will be reported faithfully. The causes of failure will be sought out, details fully given and lessons drawn therefrom. The advertisements are another marked feature of American technical journals. They are made attractive by including data of considerable educational value. Advertisements that are to be read by engineers are usually approved by other engineers, and in reputable periodicals are 99 per cent. truthful. What one leading paper says of its own advertising pages, is true of many others: "The selling section of this paper represents in reality an enormous, costly system of engineering education which comes to you every week." Incidentally, an engineer will profit by often reading the advertisements in such periodicals from cover to cover.

Details of design in the two countries are in some cases quite different. The plate girder may be cited. Wide cover plates on small flange angles are common British practice. An excellent British textbook for an illustration of a plate girder bridge makes the girders of 48-in. web plates with each flange of 4 by 4 by ½-in. angles, and two cover plates 22 by ⅜ in. End stiffeners are of 4 by 4 by ½-in. angles and intermediate stiffeners, 2 ft. 8 in. apart, of 6 by 3 by ⅜-in. tees, knee-shaped, attached to the cover plates outside the angles. Plate girder design of this type is unknown in the United States. But one row of rivets can be driven into each leg of a flange angle, and unless the web plate is thick enough to allow rivets to be calculated for double shear it may be difficult near the ends of the girders to space them close enough to take the increments of flange stress, and even with thick plates it is sometimes impracticable. Again, it is difficult to see how the small flange angles can properly distribute flange stress throughout the wide cover plates. An objection made to this type of design, on the part of American fabricating firms, is the heavy cost of smith work required by the kneed stiffeners. The question may here be asked, why the British engineer shows a fondness for the "Compound Girder" when the plate girder is often more economical?

The probability is that British and American

practice will in time be more nearly uniform than at present. Forty years ago the controversy was sharp between British and American engineers as to the relative merits of riveted and pin-connected bridges. American engineers favoured pin-connected bridges, and seldom built any other for spans of more than 100 ft. To-day riveted truss bridges of 300 ft. span are not uncommon. The Baltimore and Ohio R.R. double track bridge over the Allegheny River near Pittsburgh has a 434-ft. span with riveted joints throughout. The New York Central R. R. is now building a bridge over the Hudson River near Albany, which has one riveted truss of 400 ft. and another of 600 ft. Again, a concession to American methods is observed in comparing British practice with that of thirty years ago. More concessions will follow as competition becomes stronger.

The London County Council (General Powers) Act, of 1909, deals among other things with the regulation of Steel-Frame Buildings in the City of London. The live or "superimposed" load to be assumed for the floors of dwellings is 70 lb. per square foot, and for the floors of offices 100 lb. per square foot. These assumptions are extravagant. Many American municipalities are also guilty of excessive loading requirements. The writer in an examination made in 1918 of the building codes of 120 American cities found that two codes specified for live load on office floors, 40 lb. per square foot.; ten, 50 lb.; sixteen, 60 lb.; seven, 70 lb.; fifty-eight, 75 lb.; eleven, 100 lb. The required loads for the floors of dwellings and hotels presented the same lack of uniformity. Codes are being constantly revised in the United States, and the tendency is to lessen the live loads to be assumed on floors of the office-building type. The present New York Code calls for 60 lb. per square foot on office floors; the Chicago Code, 50 lb., and the Boston Code, 75 lb. The U.S. Department of Commerce has at present an able and representative committee endeavouring to bring about uniform requirements for floor loadings which will be at once safe and sane.

The question naturally arises: What is the live load for which office floors should be designed? The investigations made in 1893 by Blackall and Everett of the actual loading on the floors of three office buildings in Boston were so thorough that they are still quoted. The greatest floor load they found in 210 offices was 40·2 lb. per square foot, the average loading was 16·3 lb. The greatest average for ten offices in each building was 25·9 lb., 29·8 lb. and 29·0 lb., respectively. Thirty years later Mr. Blackall conducted a similar investigation of another office building in Boston. In 64 offices the maximum loading on a floor was 14·7 lb., and but four office floors were loaded over 10 lb. per square foot.

An unusually complete investigation of office-building loads was made in the latter part of 1922 by C. T. Coley, manager of the Equitable Building, New York City. (See "A Study of Office-Building Live-Loads," *Engineering News-Record*, March 29, 1923.) The 62 offices on the 11th floor of the Equitable Building had an average load of 13·96 lb. per square foot of floor area with a maximum of 33·84 and a minimum of 5·0; the 67 offices on the 20th floor averaged 10·26 lb. with a maximum of 55·4 and a minimum of 0·87; the 64 offices on the 37th floor averaged 10·67 lb. with a maximum of 30·73 and a minimum of 3·27. The maximum load of 55·4 lb. was in a room of a law library in which steel framed shelving extended from floor to ceiling. If all the shelves had been completely filled with books the average floor loading would have been 87 lb. per square foot. The Equitable Building was designed for a live load of 100 lb. per square foot on the first floor and 75 lb. on all others.

In view of the foregoing investigations it seems unnecessary to design office floors for a greater live load than 50 lb. per square foot. The writer will quote from his own specifications:—

"Buildings shall be designed for minimum live loads, in pounds per square foot of floor area as follows:—

Dwellings (private residences), first floor ...	40
Dwellings (private residences), upper floors	30
Apartment houses, first floor	50
Apartment houses, upper floors	40
Hotels, first floor	80
Hotels, upper floors	40
Office-buildings, first floor	100
Office-buildings, upper floors	50

Every steel beam in any floor used for business purposes shall be capable of sustaining a live load, concentrated at the middle, of not less than 3,000 lb." This latter clause is added to take care of safes or other concentrated loads on office floors. Regulations should be made and enforced regarding the nature of occupancy.

The London County Council Act allows exceedingly low values for pressures on masonry: 186·6 lb. per square inch on concrete foundations, and the same on blue brick in cement mortar, 124·4 lb. on hard brick in cement mortar, 78·0 lb. for ordinary brick in cement mortar. The "General Specifications for Structural Work of Buildings," by C. C. Schneider, the eminent American engineer, fairly accord with American practice, except that 500 lb. instead of 600 lb. is often used for the admissible pressure on concrete. The section relating to bearing values reads:—

"The pressure of beams, girders, wall-plates, column bases, &c., on masonry shall not exceed the following in pounds per square inch:—

On brickwork with cement mortar	300
On rubble masonry with cement mortar ...	250
On Portland-cement concrete 1:2:4 ...	600
On first-class sandstone (dimension stone) ...	400
On first-class limestone	500
On first-class granite	600."

Because of "difficulties having arisen in the interpretation of the Act, and diverse opinions having been expressed upon the meaning of some of its requirements," a strong committee from several societies made recommendations for guidance in the interpretation of various clauses. (The report embodying these was reproduced in the *Journal of the Concrete Institute*, October, 1922.) Three pages were given to column splices, the Act using the words "properly riveted," "properly fixed," when referring to the butting ends of columns. A clause in the Act reads: "The foot of every such pillar shall have a proper base-plate riveted thereto with sufficient gusset pieces to distribute properly the load on the foundations, and the gusset pieces shall have sufficient rivets to transmit the whole of the load on to the base-plates."

This seems impracticable to the American engineer with the heavy loads on many of his columns. Even in the five-storey warehouse illustrated by Cocking in his "Steel-Frame Buildings," the load on each of the bases of some interior columns is given as 400,000 lb. or more. But the report mentioned allows base-plates to be constructed with:—

"(1) A solid steel slab of sufficient thickness and area to comply with the requirements of the Act as to stresses. The load may be assumed to be carried directly from the pillar shaft into the steel slab. In such cases the pillar shaft shall be provided with angles with the bearing surfaces machined and bolted down to the steel slab with at least four bolts." If this is permissible the Act is at fault in not saying so.

The stresses obtained from the Council's requirement of 30 lb. per square foot wind pressure on the upper two-thirds of a building fairly agree with those obtained from the pressures specified in many American codes. Is this stress to be transmitted to the ground entirely by the steel framework? The question would not be raised were it not for the report, previously mentioned, stating:—

"In all cases where the walls, floors and other internal construction do not render the building sufficiently rigid to resist safely the wind pressure specified, cleated joints, knee bracing or diagonal bracing shall be provided to the steel frame in order to comply with the sub-section."

A similar ambiguity is found in many American codes. The writer has placed on record the recommendation that all steel buildings of the office type in which the height is more than twice the horizontal dimension, be designed to carry wind pressure to the ground entirely by the steel framework. Wind pressure is assumed at 15 lb. or 20 lb. per square foot, according to location. For industrial buildings not located in regions of extremely high winds, a pressure of 15 lb. per square foot on the sides and the normal component of 20 lb., as determined by Duchemin's formula, on the roof, are recommended.

That distinctive feature of American cities, the skyscraper, is barred from the City of London by the regulation that a building, not being a church or chapel, shall not be of greater height than 80 ft., exclusive of two stories in the roof and of ornamental towers, turrets or other architectural features or decorations. By this enactment the great number of buildings found in American cities more than ten stories in height—1,500 in New York alone—would all be shut out, to say nothing of a Woolworth building with offices on the fifty-third floor. The evolution of the skyscraper is a story in itself (its merits and demerits will not be discussed). Born in Chicago because of the necessity of getting more office space above a limited ground area, it spread until even cities of but comparatively small population considered it a mark of civic pride to have within their boundaries a high office building—their skyscraper. The question is often asked why the skyscraper has not found a place in the cities of Great Britain. This can best be answered by British engineers. The belief is here expressed that it will sometime find entrance even into London.

The "British Standard Specification for Girder Bridges" will be considered as representing British requirements for bridge work. Parts 1 and 2 are dated July, 1922, and Parts 3, 4 and 5 are dated August, 1923. The American Railway Engineering Association's "General Specifications for Steel Railway Bridges for Fixed Spans less than 300 Feet in Length," dated, May, 1923, commonly known as the A.R.E.A. Specifications, will be taken as representative of American requirements for railway bridges.

Part 1, *Material*, of the British Specification requires tests that seem to an American engineer severe both in kind and in number. Test pieces from plates for tensile strength and elongation are required to be cut both lengthwise and crosswise; the American manufacturer makes tests for universal mill plates from pieces cut lengthwise only. The British rules require that a tensile test be made from each heat and additional tests for every variation in thickness of 0·15 inch. The A.R.E.A. is satisfied with one tensile and one bending test from each melt, except that if material from one melt differs $\frac{3}{8}$ inch or more in thickness, one tensile and one bending test shall be made from both the thickest and the thinnest material rolled. The American manufacturer would object to making bending tests "from each plate, section or bar (other than rivet bars) as rolled," also to furnish "exact" length, to within $\frac{1}{8}$ inch over or under the length specified.

Part 2, *Workmanship*, contains several requirements that are contrary to American practice. A greater amount of planing is required. More severe still is the section:

"*Drilling, Punching and Reaming.* All rivet holes shall preferably be drilled through the solid metal, but holes in plates and sections up to three-quarters of an inch thick may be punched and reamed, and holes in floor plates, packings, tie-plates and lacing bars, up to one-half of an inch thick may be punched full size, if so arranged by the Engineer (or the Purchaser) previous to the acceptance of the Contractor's tender."

Quite in contrast to this are the A.R.E.A. requirements, namely:—

"The work shall be 'Punched Work' or 'Reamed Work' as stipulated. In punched work, holes in material whose thickness is not greater than the diameter of the rivets plus $\frac{1}{4}$ inch, may be punched full size. Holes in material of greater thickness shall be drilled. In reamed work, holes in material $\frac{7}{8}$-in. thick and less, used for lateral, longitudinal and sway bracing, lacing, stay plates and diaphragms, may be punched full size. Holes in other material $\frac{3}{4}$ in. thick and less, shall be sub-punched and reamed. Holes in other material more than $\frac{3}{4}$ in. shall be drilled."

A requirement of the British Specification is:—

"The whole of the steelwork shall be temporarily erected in the Contractor's works for the inspection of the Engineer or the Inspector before being despatched, a sufficient number of temporary bolts

being well screwed up in the holes, left to be filled with rivets at the site."

The A.R.E.A. considers the following sufficient:

"Solid floor sections shall be assembled to the girders or trusses, or to suitable frames, in the shop, and the end connections made to fit. In reamed work, riveted trusses and skew portals shall be assembled in the shop, the parts adjusted to line and fit, and the holes for field connections drilled or reamed while so assembled. Holes for other field connections, except those in lateral, longitudinal and sway bracing, shall be drilled or reamed in the shop with the connecting parts assembled, or else drilled or reamed to a metal template. In punched work the field connections (except those in lateral, longitudinal and sway bracing) shall be reamed to metal templates. Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished the Engineer."

Part 3. *Loads and Stresses.* A marked feature of the British Specification is the permissible working stresses. For axial tension, net section, a stress of 17,920 lb. per square inch is allowed against the 16,000 lb. permitted by the A.R.E.A. For axial compression, the formulas 17920–60 l/r for columns with riveted end connections and 17920–90 l/r for those with pin end connections, with a maximum of 15232, are used against the A.R.E.A. formula, 15000–50 l/r for all cases, with a maximum of 12500. For shear in web plates, 11200 is given against 10000; shear in rivets, 13440 against 12000; bearing on rivets, 26880 against 24000.

The British engineer has ground for his criticism of the A.R.E.A. using the same formula for columns and struts regardless of end connections. In his Specifications for Railroad Bridges, 1900, Schneider uses the same column formula for both pin and riveted ends. In his Specifications for the Structural Work of Buildings he added a footnote:

"The effective length, l, if L is the length of the member between centres of connections, shall be taken as follows:—

l = L, if both ends are hinged or butting;
$l = \frac{1}{2}$ L, if both ends are fixed;
$l = \frac{2}{3}$ L, if one end is fixed, the other hinged;
l = 2 L, if one end is fixed, the other free to move."

The British impact formula differs from both that of the old (1910) and the present formula of the A.R.E.A. giving higher values in some cases and lower in others.

The allowable bearing values of bedplates on footings adopted by British engineers are unusually low; 390 lb. per square inch on granite, 311 lb. on sandstone, and 233 or 280 lb. on cement concrete. The A.R.E.A. allows 800 lb. per square inch bearing on granite masonry, 400 lb. on sandstone and limestone masonry and 600 lb. on concrete masonry. Some railroads, when allowing 600 lb. bearing, use a layer of steel reinforcement on the top of concrete piers and abutments; others use lower bearing values.

Part 4. *Details of Construction*—The section pertaining to plate girders presents an opportunity for academic discussion. but this may be said of the plate girder in all specifications. It is noted that bearing and shearing values of rivets are determined from the diameter and area of the rivet hole, and not from the nominal diameter and area of the rivet itself, as in American practice. Also for net section the actual diameter of the rivet hole is deducted, while in American practice the diameter of a hole one-eighth larger than the nominal diameter of the rivet is deducted.

The requirements for splicing compression members are quite different in the two specifications. The British Specification reads:—"The butting ends of all spliced members, whether in tension or compression, shall be fully covered and riveted to develop the effective strength of the members."

The A.R.E.A. requirements on the other hand are:—"Abutting joints in compression members faced for bearing shall have component parts spliced. The gross area of the splice material shall be not less than 50 per cent. of the gross area of the smaller member. In determining the number of rivets in compression splices, the stress in the splice material shall be taken as 15,000 lb. per square inch of gross area. Joints in riveted work not faced for bearing, whether in tension or compression, shall be fully spliced."

Part 5, *Erection*, of the British Specification, varies but little from usual American practice.

From the foregoing a summary of British and American bridge practice may be as follows:

1. The British Specification requires a higher grade of material and workmanship than the A.R.E.A. Specifications. As already mentioned, or inferred, some of these requirements seem to the American engineer more severe than necessary.

2. Due to the higher working stresses used, bridges should weigh less when built with British than under American Specifications. However, the additional labour incurs a greater expense and longer time is required for fabrication.

3. More is left to the decision of the engineer in the British Specification than in the American. The wisdom of this is not apparent. Many points of design could as well be settled by the specifications as at a later date by the engineer. The 289 paragraphs of the A.R.E.A. Specifications convey to the designer at the outset exactly what he wants to know.

In conclusion, it may be said that from the American point of view the British engineer gives undue weight to precedent, and is too prone to stick to the past. The charge sometimes brought against the American engineer is that he is too keen for originality and too eager for something new. Good precedent is undoubtedly better than indifferent originality, but without originality no progress can be made.

NOTES.

The Birthday Honours.

The customary long list of honours, granted by His Majesty the King on the occasion of his birthday to those who have rendered exceptional service to the Empire, again contains the names of a number of engineers. Prior to referring to the recipients who are actually members of the engineering profession, attention should be called to the viscountcy conferred upon Lord Bearsted, the founder of the Shell Transport and Trading Company and its associated organisations. Lord Bearsted has made numerous public benefactions. among which may be mentioned the gift of 10,000*l.* last year to the University of Sheffield for the encouragement of study and research in metallurgy. The appearance of the names of Mr. Hugo Hirst and Lieut.-Colonel James Lithgow, M.C., in the list of baronetcies, will give pleasure to the members of two sides of the engineering profession. Mr. Hirst is well known as the guiding hand of the many engineering organisations associated with the General Electric Company, Limited, and Lieut.-Colonel Lithgow, the President of the National Confederation of Employers Organisations, occupies a prominent position among British shipbuilders. Mr. H. E. Blain, who receives a knighthood, was for many years assistant managing director of the London Underground Railways. Sir John F. C. Snell, the Chairman of the Electricity Commission, has been granted the G.B.E., while the knighthood of the same order has been conferred on Mr. Frederick T. Hopkinson, M.Inst.C.E., for services in connection with the Nile Dam, and on Sir John Reid, of the North British Locomotive Company, Limited, for many public services. Among the names of those who receive the C.B. we note Eng. Rear-Admiral H. B. Moorshead, C.B.E., Mr. Charles F. Munday, the Deputy Director of Naval Construction, and Colonel George Walker, Chief Engineer of the Eastern Command of the Army. The distinction of C.B.E. has been conferred on Eng.-Captain C. H. A. Bermingham, R.N.; Lieut.-Col. Ernest Robinson, of the Tyne Electrical Engineers, Territorial Army; Colonel J. G. Riddick, D.S.O., R.E.; Mr. Austen Boyce, of the Survey Department of the Sudan Government; Mr. Francis Carnegie, M.Inst.C.E., of the Royal Arsenal; Colonel Ivor Curtis, A.M.I.Mech.E., of the Air Ministry; and Mr. Ernest A. J. Pearce, R.C.N.C., Director of Warship Production at the Admiralty.

The Australian Navy Contracts.

It is now announced by the High Commissioner for Australia, Sir Joseph Cook, that the contracts for new cruisers and submarines, amounting to nearly 3,500,000*l.*, have been placed with British shipbuilders. The decision to build these vessels in British yards at the present time will be appreciated by all who have knowledge of the conditions of unemployment in the shipbuilding and steel industries of this country. The two cruisers are to be of 10,000 tons each and will be built at Clydebank by Messrs. John Brown and Co., Limited. These vessels are to be similar to those of the "County" class under construction for the Royal Navy. The main armament for one of the vessels is to be supplied by Messrs. Vickers, Limited, and for the other by Sir W. G. Armstrong, Whitworth and Co., Limited. Contracts for gun mountings have already been placed with each of these firms, at approximately 350,000*l.*, and the further requirements will shortly be ordered. The steel companies who receive the armour-plate contracts are Messrs. William Beardmore and Co., Limited, of Glasgow, Messrs. Cammell Laird and Co., Limited, of Sheffield, and Messrs. David Colville and Sons, Limited, of Motherwell. Two submarines form part of the present programme, and the contracts for these have been placed with Messrs. Vickers, Limited, of Barrow-in-Furness. Last year a naval-development programme was agreed upon by the Commonwealth Government and the construction of these vessels is in accordance with the decisions then made. This programme will involve the expenditure of 1,000,000*l.* a year for five years, quite exclusive of the cost of the vessels referred to and also in addition to the ordinary maintenance and administrative costs of the Royal Australian Navy, which, for the year 1924, will amount to 2,354,000*l.* At the present time, the Royal Australian Navy has four cruisers, three of which are in commission, but as they are of 5,800 tons, it will be appreciated that the new cruisers are to be the largest war vessels on the southern seas. The other components of the naval arm of the Commonwealth consist of a flotilla tender, eleven destroyers, five of which are of the "S" class and the others of the type designed for use on Australian rivers. There are also three sloops, a depot and repair ship and a surveying ship.

The Royal Sanitary Institute.—It is announced that the Thirty-sixth Congress of the Royal Sanitary Institute will be held at Edinburgh from July 20 to 25 of this year. H.R.H. the Duke of York has accepted the office of Honorary President of this Congress, over which Sir John Gilmour, M.P., Secretary for Scotland, will preside. Sectional meetings will be held dealing with sanitary science, engineering, architecture, and industrial hygiene, while some eight conferences will take place, including those for engineers and surveyors, representatives of sanitary authorities, and representatives of port sanitary authorities. A programme of events has been published, copies of which may be obtained from Mr. E. White Wallis, Secretary and Director, the Royal Sanitary Institute, 90, Buckingham Palace-road, London, S.W.1.

Contracts.—Messrs. Howden-Ljungström Preheaters (Land), Limited, of 133, Helen-street, Govan, Glasgow, have received an order to supply one preheater to Messrs. Thomas Chalmers and Sons, Limited, of Loch Paper Mill, Linlithgow.—A contract has been placed, at a price of 63,300*l.*, with the International Electrolytic Plant Company, Limited, of Chester, by the Société des Phosphates Tunisiens, of Paris, for an installation of 600 standard Knowles cells, each capable of passing 7,500 amperes. This installation is intended for service at Soulom, near Lourdes, France, the hydrogen liberated by the electrolysis of water being used for the manufacture of synthetic ammonia.—The West Dean Rural District Council have placed a contract with Messrs. George Stow and Co. for sinking a well through old red sandstone, at a cost of 1,875*l.* This well forms the first unit of a large water-supply scheme for the rural area. The supervising engineers are Messrs. W. H. Radford and Son, of Nottingham.—The Mirrlees Watson Company, Limited, of Scotland-street, Glasgow, have secured an order for de-aerating and evaporating plant, capable of treating 150,000 lb. of feed-water per hour, for use at Ipswich Corporation Electricity Works.—Messrs. Ed. Bennis and Co., Limited, of 28, Victoria-street, Westminster, London, S.W. 1, have secured, amongst others, orders from the Ocean Coal Company, Limited, of Treorchy, for four mechanical stokers and self-cleaning compressed-air furnaces for use with Lancashire boilers; for three sprinkler stokers and self-cleaning compressed air furnaces from the Bridlington Corporation Electricity Station; and for 16 sprinkler stokers and a 1924 type natural-draught furnace from the Decca Twist Company, of Portland-street, Manchester.

LETTERS TO THE EDITOR.

THE THEORY OF THE MICHELL BEARING.

To the Editor of Engineering.

Sir,—I have read with some interest the article on "Practical Notes on the Theory of the Michell Bearing," by Mr. W. R. Needham, which appeared in the issue of Engineering for February 13 last. So far as the first part of the article is concerned, no comment is necessary, except that a misprint occurs in equation (3) where the term L should be replaced by W.

After giving, however, a very useful summary of all the available data relating to loading conditions and frictional resistance for a rectangular bearing surface, the author proceeds to indicate how the quantity of oil necessary for efficient lubrication can be obtained by assuming that the temperature of the oil rises 25 deg. F. as it passes between the surfaces, and then equating the heat contents of the oil to the heat equivalent of the friction work. This assumption of a definite temperature rise is open to criticism and can only lead, as Mr. Needham certainly points out, to a very rough approximation. With the data at the author's disposal it provides, admittedly, the only possible method, but it would appear to be more logical and possibly more accurate, in spite of the various uncertainties which influence problems of this type, to reverse the procedure; that is to say, to determine the quantity theoretically and then utilise the amount thus obtained to find the rise in temperature.

As I have the necessary data which enables this to be done, I am taking the liberty of adding to Mr. Needham's article by considering the question from this new point of view, the change of procedure being justified since it will be shown that as the temperature rise of the oil is directly proportional to the load carried by the surface per unit area, it cannot, with any degree of accuracy, be assumed to be constant for all conditions of loading as might be inferred from the article.

The notation used by Mr. Needham will be adhered to throughout, the suffix E being attached to all symbols which represent the English system of units. The volume of oil that passes through the inlet edge and enters the wedge-shaped space between the two surfaces can be expressed in the form

$$\text{Volume} = U \cdot h \cdot W \cdot V \text{ cub. cms. per sec.}$$

where U is the velocity of the moving surface in cms. per sec., h the film thickness at the outlet edge, W the traverse width of the surface in cms., and V is a constant depending upon the ratio of inlet to outlet film thickness and also upon the ratio between the length L and width W of the bearing surface.

The load carried per centimetre width of the surface is

$$P = \frac{\lambda \cdot U \cdot L^2}{h^2} \cdot \phi \text{ dynes,}$$

so that since $P = p \cdot L$, where p is the load per unit area, the volume can be written in the form

$$\text{Volume} = U \cdot L \cdot W \cdot \left(\frac{\lambda \cdot U}{p \cdot L}\right)^{\frac{1}{2}} (\phi^{\frac{1}{2}} \cdot V) \text{ cub. cms.}$$

Converting this so that U is measured in feet per sec. L and W in inches, and p in lbs. per square inch, the volume of oil required for each pad in gallons per minute will be given by

$$\text{Volume} = U_E \cdot L_E \cdot W_E \left(\frac{\lambda \cdot U_E}{p_E \cdot L_E}\right)^{\frac{1}{2}} \cdot V_E$$

where

$$V_E = 0{\cdot}03425\ \phi^{\frac{1}{2}} \cdot V.$$

If the specific heat of the oil is now denoted by S and the weight is assumed to be D lbs. per gallon, the heat absorbed for a rise in temperature of T deg. F. will be

$$\text{Volume in gallons per minute} \times S \cdot D \cdot T$$

B.Th.U. per minute.

The friction work has been shown by Mr. Needham to take the form

$$60\ C_E \cdot U_E \cdot W_E (p_E \cdot L_E \cdot \lambda\ U_E)^{\frac{1}{2}} \text{ ft.-lbs per minute.}$$

or, dividing by 778, is equivalent to

$$0{\cdot}077\ C_E \cdot U_E \cdot W_E (p_E \cdot L_E \cdot \lambda \cdot U_E)^{\frac{1}{2}} \text{ B.Th.U. per min.}$$

If it is now assumed that all the friction heat is transmitted to the oil, it follows directly that

$$p_E = 12{\cdot}97 \left(\frac{V_E}{C_E}\right) \cdot S \cdot D \cdot T \text{ lb. per sq. in.}$$

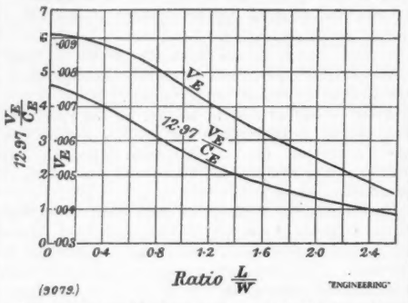
That is to say, the rise in temperature of the oil is entirely dependent upon the load per unit area carried by the surface and is independent of both the velocity of the moving surface and the viscosity of the oil.

Values of the two constants $12{\cdot}97\ \frac{V_E}{C_E}$ and V_E for different length to width ratios are given in the accompanying Table I., and in the diagram, the usual assumption being made that the ratio of inlet to outlet film thickness is 2·0.

Applying these conditions to the numerical case cited by Mr. Needham, in which

Total load	.... 7,000 lb.	Viscosity	.... 0·2
Mean length	.... 4 in.	Specific heat	0·375
Width	.... 5 in.	Weight	.... 9 lbs. per gallon.
Area	.... 20 sq. in.	Velocity	.... 40 ft. per sec.

it will be found that since the load per unit area is 350 lb. per square inch and the value of the constant $12{\cdot}97 \left(\frac{V_E}{C_E}\right)$ for a length to width ratio of 0·8 is 3·13, the temperature rise of the oil film will be 33·2 deg. F.



Similarly, since V_E has the value 0·0081, the volume of oil required for the effective lubrication of the bearing surface is 0·490 gallon per minute. The corresponding values taken from Mr. Needham's figures are 25° F. and 0·662 gallon per minute. That is to say, the actual temperature rise is 8·2 deg. F., or 33 per cent. higher than the assumed value, while the quantity of oil shows a decrease of 0·172 gallon per minute or 26 per cent. less. From the data now given, it should be obvious that a temperature rise of 25 deg. F. is actually associated with a load of about 265 lb. per square inch, the amount of oil required for this case, assuming that the velocity and other factors remain unaltered, being 0·565 gallon per minute.

Table I.—*Values of Constants.*

Note.—The values of C_E are given in the original article.

$\frac{L}{W}$	0	0·5	0·8	1·0	1·5	2·0	2·5
V_E	0·0091	0·0087	0·0081	0·007[illegible]	0·0064	0·0055	0·0046
$12{\cdot}97\left(\frac{V_E}{C_E}\right)$	4·63	3·80	3·13	2·64	1·85	1·30	0·92

The discrepancy between the two methods appears to be worth consideration.

I remain, yours faithfully,

Robert O. Boswall.

College of Technology, Manchester.
May 20, 1925.

BOILER TRIALS.

To the Editor of Engineering.

Sir,—Referring to the article on "Boiler Trials" in your issue of April 3 last, do the Commission propose that the rating be dictated, or governed, by economical commercial considerations or by scientific endeavours to attain the highest thermal efficiency and evaporative power? After defining a boiler as including all the elements the principal function of which is the transmission of heat from the fire and heated gases to the water and steam, as well as those elements mainly intended for the storage or accumulation of steam or water, up to and including the stop valve, we may specify the scientific or highest thermal efficiency rating of such a boiler or steam generator as that rating corresponding to the evaporative power at the highest thermal efficiency.

In the ideal boiler or steam generator, the highest thermal efficiency will be obtained by bringing the temperature of the gas, and other products, down to that of the surroundings, as in the calorimeter, by means of suitably-arranged elements for heating the incoming feed-water or air of combustion. The unavoidable losses will thus be reduced to: (1) radiation, conduction, &c.; (2) combustible materials in ash.

Owing to the multitude of influences bearing on the subject of the most economical commercial rating, most of the factors involved being of a financial character and therefore varying for different localities even for the same boiler, it is not to be expected that the two ratings should coincide or even approximate to one another. It may therefore become commercially economical to work a boiler at far beyond its rated capacity for highest thermal efficiency and show a net gain financially after discounting the losses due to reduced thermal efficiency. As an instance of everyday occurrence, a ship may sometimes avoid a much greater loss than that due to the cost of the extra fuel used in driving her boilers beyond their rated capacity for greatest thermal efficiency in order to meet the needs of a special occasion.

The foregoing remarks should make clear the impossibility of reconciling the two points of view for rating boilers, or, indeed, any other industrial apparatus.

Yours faithfully,

Thomas Le Gall.

Rio de Janeiro, May 8, 1925.

THE FINENESS OF PORTLAND CEMENT.

To the Editor of Engineering.

Sir,—I have read with great interest the letter from your correspondent Mr. J. Carr-Archer, in the current issue of Engineering. The question asked "What is cement flour?" is one that has been put to me hundreds of times, when explaining the Flourometer. The only explanation I can give, having adopted the name, is as follows:—From the fact that the tensile strength with the finer cement was greater than that of coarser cement, quite outside any possible variation through other causes, I concluded that some part of the cement as a whole must be of more cementitious value than the rest, depending on the grinding. For my own information, I started experimenting to try and separate them, and the Flourometer was evolved. The principle of this consists in driving a given quantity of air at a certain pressure through a given quantity of cement, the particles which are light enough being carried up through an uptake of a certain size. These particles were then deposited in a receptacle, the residue remaining where the air is blown through it. The lighter particles I called, for want of a better name "Flour." Thousands of tests were made, not only to obtain flour and residue for testing purposes, but also to decide the line of division between them and adjust the Flourometer to divide them at exactly the right point. A conclusion arrived at was that, at a certain stage of reduction, the particles combined by calcination are separated, and, although incapable of combining with or being acted upon by water while combined with other such particles, when separated they become softened and capable of taking up water and setting. The name "Flour" is not used in the same sense as powder, but, in the case of cement, means that part of the cement that is soluble or capable of combining with water and setting and hardening. Before definitely fixing the standard figures or quantities, the late Mr. Bertram Blount was kind enough to have a Flourometer and, over some months, check my figures, with which he agreed, and he influenced me to put the Flourometer on the market. With regard to another question raised, *viz.*, the appearance of the residue after soaking in water, I have made such tests and found that there was little or no difference in the appearance of it after drying. There is, however, one thing with which I do not agree, *viz.*, that in a tube mill, the reducing is effected by blows. My opinion is based on an experience in grinding and separating cement dating from as far back as 1872. At one period, about 1901, from 50 to 75 per cent. of the whole of the cement then manufactured in the British Isles, as well as a fair proportion of that in France, was being ground, &c., by machinery for the installation of which I had been instrumental. I contend that in a tube mill the grinding is effected by the cement getting between the points of contact between the pebbles as they roll over. The quantity of cement between the points of contact being smaller as the cement gets finer would account for the output being smaller. I am of the opinion that the finer the cement required the more is rubbing down necessary. It is quite possible to lift or take out whole or part of the flour and grind the residue. This would not be so satisfactory as grinding the cement all together to the necessary fineness, even with rotary kiln ground cement, although this is burnt so regularly. With regard to the relative value of the tube mill, as compared with the old millstones, the reason why the ball and tube mills have been so fully adopted is because of the great reduction or elimination of skilled labour and saving the time taken up in dressing of millstones. Some years since, I patented an iron millstone and reduced this loss as well as saved a large proportion of power. I substituted a pair of these in place of the ordinary burr millstones that were grinding to the ordinary fineness at that time 14 cwt. per hour for over 30 indicated horse-power. My patent stones gave over 30 cwt. per hour for only 14 indicated horse-power. It, therefore, appears to be possible to make improvements that will enable cement to be ground by rubbing to meet the coming or increasing demand for finer cement. In conclusion,

apart from the saving made generally by using cement with an increased proportion of flour, by enabling a larger proportion of sand to be used the economy will be more evident when a heavy carriage or freightage is incurred; provided of course there is good sand or other material on the spot.

WILL. F. GOREHAM,
Inventor of the Flourometer.
52, Flanders Mansions, Bedford Park, W. 4.
May 30, 1925.

HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

TO THE EDITOR OF ENGINEERING.

SIR,—In connection with the point raised by Professor Gibson with regard to the efficiency of bent draught-tubes in the hydro-electric plant at Forshuvudforsen described in your issue of February 20 on page 217, it might be of some interest to mention the results of the experiments on the flow of water in diverging rectangular passages, which have just been finished in our laboratory, and the full particulars of which will soon be published. In the experiments, the pressures at several points along the passages and the rate of flow were measured, and from these data the total energy of flowing water per unit weight at each section, where the pressure was observed, was calculated by assuming that the pressure was uniform upon the whole section, and that all the particles of water at the section had the same mean velocity. The difference of the total energies thus calculated between any two sections may be termed the apparent loss of head between these two sections. Then the result of the experiments shows that the apparent loss of head along a diverging passage usually increases as the flow of water proceeds, but after leaving the diverging part it decreases gradually in the succeeding parallel passage, the area of which is the same as that at the end of divergence. If measurements were made along the bent draught-tube in a similar manner as in our experiments, and if there were any possibility of decrease in the apparent loss of head between the measured points, the efficiency, or more properly the apparent efficiency, of the bent tube might easily become greater than unity.

Yours faithfully,
KAZU SHOGEUJI.

Kyushu Imperial University,
Fukuoka, Japan.
April 15, 1925.

LABOUR NOTES.

MR. FRANK SMITH, the Secretary to the Engineering Trade Unions' Joint Movement, has now received the reply of the Engineering and Allied Employers' National Federation to his letter of May 21. The unions' letter of May 21 intimated, it will be recalled, that the representatives of the men declined to negotiate the wages application on the basis proposed. The employers, in their latest communication, give a brief summary of the negotiations that have taken place, and proceed:—

"It would appear that the proposal of the employers of April 22 has been looked upon, not as a proposal for acceptance by employers and workpeople as a mutual effort to revivify the industry and create employment, but as a reply to an application for advance in wages unconditionally. If so, an unfortunate mistake has been made. Any advance in wages without compensating conditions is impracticable. The employers have asked the unions to join with them in their endeavour to restore the industry. They have proposed a joint approach to the Government on the question of international hours of labour; they have undertaken to review the situation when competitor nations effectively bring their hours into closer relation with those in this country; and they have asked the unions to consider the proposal with due regard to the vital necessities of the industry.

"The employers are unable to bring themselves to the conclusion that the circumstances of the case and the necessities of the industry can be met by a resolution of such a general and negative character as that adopted by the union representatives on May 20, viz., 'That this conference of executive representatives concerned in the wage application for 20s. per week declines to negotiate the wage application on the basis suggested in the Engineering and Allied Employers' National Federation's letter, dated April 22, 1925.'

"The situation has, since we last met you, become more serious, and the industrial position is one of extreme gravity. My board feel that the unions, having a direct interest in maintaining and furthering the interests of the workpeople, must be asked to apply their minds with much greater precision to the situation.

"It is to be hoped that the gravity of the situation will convince your representatives of the necessity of going much more deeply into the position than is apparent from the resolution of May 20. To assist your representatives in this direction I am desired to say that the offer of a further conference is still open. I am desired to express the hope that the whole subject will be again considered by your representatives and that you will let me have a further reply."

After considering the Executive Council's report on the wages negotiations, the Southport meeting of the National Committee of the Amalgamated Engineering Union passed a resolution expressing appreciation of the efforts that had been made, and recording disappointment at the failure to secure an advance. The delegates put on record their determination to oppose to the utmost of their power the proposal of the employers to increase the working week and the suggested reduction of the rates paid for overtime and night-shift.

On Monday, the building-trade operatives employed on several of the housing schemes for which the local authority for the Middle Ward of Lanarkshire is responsible, ceased work as a protest against the erection of 100 Weir steel houses under other than building-trade wages and conditions. About 300 men are involved, and the effect of their action is to stop work on some 322 houses. Work is, of course, proceeding on the steel houses—in accordance with a decision arrived at by the Middle Ward Committee at a meeting in Glasgow on Friday. By a small majority, it was resolved to set up a sub-committee to inquire into the methods adopted by Messrs. Weir in the manufacture, assembly and erection of the Weir house, and to report on whether they are, or are not, implementing their contract. When the result of these investigations is available, the Committee will decide for itself whether Messrs. Weir's interpretation of the fair wages clause or that of the building trades is the true one. It was suggested that work should be suspended on the steel houses until the inquiry was concluded, but the Committee decided to allow the operations to proceed. The building-trade unions, therefore, decided to strike.

At its meeting in Southport last week, the National Committee of the Amalgamated Engineering Union passed the following resolution: "That this National Committee of the Amalgamated Engineering Union, having heard the report of the president in regard to the interview between the Prime Minister and the Executive Council on May 12, 1925, with reference to the resolution passed by the National Committee in September, 1923, calls upon the Government to provide suitable employment for skilled mechanics at full trade-union rates. Further, that the committee instructs the Executive Council to approach the Engineering and Allied Employers' National Federation with a view to making joint representations to the Prime Minister to secure the ratification and observance of the findings of the Washington Convention with regard to the hours of labour."

M. Durafour, the French Minister of Labour, made an interesting announcement on the subject of the Washington Eight Hours' Day Convention at Geneva on Wednesday of last week. According to the *Manchester Guardian's* correspondent, he said that efforts to secure ratification by many States had failed, and new diplomatic methods were now to be tried. He hoped that the conference of the Labour Ministers of Belgium, Great Britain, France and Germany last September, at Berne, would be followed by another in London towards the end of June. The workers' group was not represented at Berne, but he was in favour of the attendance at the London conference of the Labour organisations of all four countries. He expressed confidence that the Labour Ministers would agree on the questions of interpretation and application, and then engage themselves to recommend to the Parliaments of their countries the simultaneous ratification of the unmodified Washington Convention.

According to returns published in Berlin, the number of persons receiving full-time unemployment relief in Germany sank during the first half of May from 320,000 to 274,000. On April 15 it was 390,000 and on January 1, 586,000.

In accordance with the recommendations of the Anglo-Russian conference on trade-union unity, the All-Russian Council of Trade Unions has again approached the International Federation of Trade Unions whose council in February last, it will be remembered, laid down as a condition of negotiations with the Russian unions that they should formally apply for affiliation. The All-Russian Council declares that it is in favour of the single international. "Our aim," it says, "and the aim of the majority of the class-conscious workers of the world, is the creation of a single international of the trade unionists of all countries who accept the principle of the class war and the ultimate liberation of the workers from the yoke of capital. . . . The trade unions of the Soviet Union are prepared to adhere to a single international of trade unions whose statutes would not be very different, in their broad features, from those of the Amsterdam International." The difficulty is, of course, that the "statutes" of the Red International have features which Amsterdam cannot adopt, whereas there is nothing in those of the Amsterdam International to which Moscow can take exception. The defect of Moscow in the eyes of Amsterdam is, in fact, that it goes too far. Another obstacle to the formation of a single international on the lines proposed, is that Moscow desires the inclusion of all the trade unions outside Russia not at present affiliated to Amsterdam. The "Red" unions indicated have antagonised the Amsterdam unions in many countries to such an extent that their inclusion is certain to be bitterly opposed. Still, a conference to re-discuss the whole position is not improbable, although it is unlikely to make much progress towards the end desired by the Russians.

In the fifth annual report of the Industrial Fatigue Research Board, it is suggested that industry generally might do more to promote the objects which the organisation seeks to achieve than it does at present. The response to its appeals for co-operation have, so far, been disappointing. "The Board think," the report says, "that this apparent indifference may be due, first, to the fact that representatives of industry are, and have been in recent years, fully occupied with the discussion of questions calling for immediate settlement, and have little time left for consideration of the future; secondly, to the financial stringency that has existed through the time of industrial depression; and, lastly, to failure to appreciate the real points at issue. They suggest, however, that, just as in the past many difficulties would have been avoided by the adoption of some machinery to concentrate entirely on the future, so in this particular subject opportunities may be lost unless steps are now taken to look ahead. For there are unmistakable signs that, in other countries, the importance of the human factor in relation to production is gaining increased acknowledgment every year, and the speed with which this relationship can be developed in this country is contingent, not on the efforts of small bodies with limited resources, but on the initiation of a definite movement on the part of industries themselves."

Two features of the Board's work are, therefore, emphasised—features which have clearly emerged during the last six years. It is pointed out that the past history of factory legislation shows that the successive industrial reforms introduced were justified by their supporters mainly on humanitarian grounds, it being generally assumed, in the absence of any evidence to the contrary, that the workers alone would benefit and (as admitted even by the reformers themselves) that the manufacturers might suffer. Probably the most important result of the Board's work has been to prove that the worker's well-being is not antagonistic to production, but that maximum production is contingent on maximum fitness on the part of the worker. The conditions underlying the maximum fitness are not, in the Board's opinion, completely understood: new knowledge is being constantly acquired. Indications as to how improvement in this respect can be secured "are surely worthy of serious attention on the part of industry, if only for the reason that, from the very method of assessment, strong evidence exists that they will benefit the employer no less than the workman."

The other feature is the loss which arises from the present indifference to the physiological and psychological aspects of industry. It is recalled that the Chief Medical Officer of the Ministry of Health, in his 1923 report, estimates that the loss of time due to sickness, most of which is preventable, probably costs the country not less than ten times more than that which it loses owing to strikes and labour disputes. "The Board, therefore, are inclined to suggest that industries which are not at present disposed to regard these questions as an important factor in their national progress should arrange for a short survey by a qualified person of their existing conditions on an economic basis, the conclusions reached being, of course, accompanied by the data supporting them. If this were done, even on comparatively superficial lines, the results, in the conviction of the Board, would be such as to persuade

the most conservative that here a field of enormous potentialities lies open to exploration in every class of industry."

The Ministry of Labour states that, on May 25, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,186,100—925,100 men, 32,900 boys, 199,800 women, and 28,300 girls. On May 18, 1925, the number was 1,185,020—912,804 men, 34,183 boys, 207,492 women, and 30,541 girls—and on May 26, 1924, it was 1,015,626—754,553 men, 33,669 boys, 194,893 women and 32,511 girls.

According to the Bureau of Statistics and Information, the volume of factory employment in New York State increased by a little over one per cent. in March. This, together with the two per cent. increase in February, constitutes, it is claimed, a good seasonal gain. There were still, however, about 78,000 fewer workers on factory payrolls than in March, 1924, the month before the last phase of the depression set in. The tendencies in the individual groups are still not well defined, and some industries are not consistently responding to improved conditions. For these reasons, the upward movement cannot yet be said to have acquired much momentum. Some industries, which have been improving materially in recent months, declined in March. While the number of employees increased but slightly, additions to working time, and wage rate increases, were influential in bringing about a 3 per cent. addition to the total wage payments in March. The increase, however, has to be interpreted with February holiday observances in mind. These were responsible for low payrolls in that month. Average weekly earnings were about 30 cents above those of a year ago. March was also the first month since the depression when the number of workers affected by wage-rate increases exceeded those affected by decreases. A few increases that restored old rates, and the drawing to a close of wage-rate reductions in textiles, largely explain this situation.

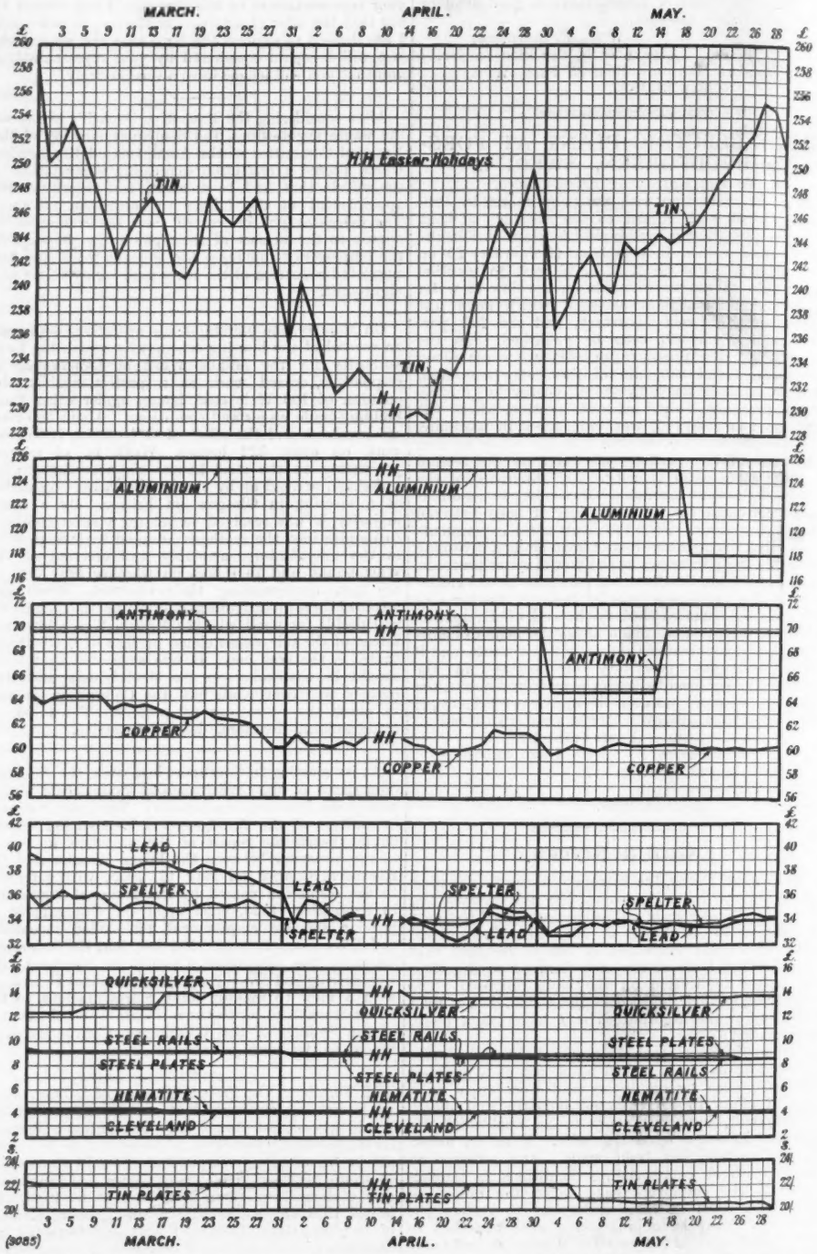
THE IRON AND STEEL INSTITUTE: ERRATA.—In dealing with the remarks by Mr. H. H. Ashdown, on page 597 *ante*, we stated that ". . . the clinks were right in the interior of the inclusions." This should read ". . . the inclusions were right in the interior of the clinks." Lower down in the same report the word "rapidly" should be deleted.

BRITISH WATERWORKS ASSOCIATION.—The fourteenth annual general meeting of the British Waterworks Association will be held on July 1 in the Council Chamber of the Guildhall, London. This year the British Waterworks Association and the Institution of Water Engineers will hold their summer meetings in the same week. On July 2, members of both organisations will visit the Staines and Littleton Reservoirs and other works of the Metropolitan Water Board, while the inspection of the works of the East Surrey Water Company at Purley and Reigate will take place on the following day. Representatives from America, the Colonies, and from the majority of the water undertakings in the United Kingdom will be present at the annual dinner on July 1. Special railway facilities will be available from June 29 to July 6. Vouchers entitling travellers to special fares may be obtained by those who wish to attend the summer meeting on application to the Secretary of the Association, Mr. Warner Terry, 173, Rosebery-avenue, London, E.C. 1.

THE BRITISH ASSOCIATION.—The British Association will hold its full-week meeting this year from Wednesday, August 26, to Wednesday, September 2, at Southampton, under the presidency of Dr. Horace Lamb, F.R.S., Professor of Mathematics at Manchester, who will deliver his inaugural address in the Central Hall at 8.30 p.m. on Wednesday, August 26. Most of the sections will find accommodation in Southampton University College, but the three sections, in which we are more particularly interested, will have their own meeting places:—Section G, Engineering, in the Central Hall; Section A, Mathematics and Physics, in the Lamb Memorial Hall; and Section B, Chemistry, in Kell Hall. The officers, presidents and recorders of these sections are: G—Sir Archibald Denny, Bart., and Professor F. C. Lea, Sheffield University; A—Dr. G. C. Simpson and Professor A. M. Tyndall, Bristol University; B—Professor C. H. Desch and Dr. H. McCombie, King's College, Cambridge. Enquiries as to papers should be addressed to the recorders, and general enquiries to the Secretary of the British Association, Burlington House, Piccadilly, W. The reception room at Southampton will be in King Edward VI School. In his presidential address to Section G, Sir A. Denny will deal with "Fifty Years' Evolution in Naval Architecture and Marine Engineering"; Dr. Simpson will address Section A on "The New Idea in Meteorology," and Professor Desch, Section B, on "The Chemistry of Solids." Gas ignition and transport problems are among the subjects to be discussed in Section G. The one evening discourse is to be given by Mr. R. V. Southwell, of the National Physical Laboratory, on "Aeronautical Problems of the Past and Future," and the presidential address of Dr. T. Ashby to Section H, Anthropology, on "Practical Engineering in Ancient Rome," will likewise be of interest to engineers.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams, the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal, respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates, are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lb. to 80 lb. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

SIAMESE GUNBOAT "RATANAKOSINDR."—The river gunboat Ratanakosindr, under construction by Sir W. G. Armstrong, Whitworth and Co., Limited, for the Royal Siamese Government, was recently launched from the builder's yard at High Walker-on-Tyne. The vessel has an overall length of 175 ft., a moulded breadth of 36 ft. 6 in., and a moulded depth, to the upper deck, of 14 ft. 11½ in. The draught under normal conditions will be 10 ft. 9 in. Intended for river, estuary, and coast line patrol work, the dimensions and displacement are of necessity limited. Notwithstanding her small size, however, a formidable combination of offensive and defensive qualities have been incorporated in the design of the vessel without exceeding a normal displacement of 1,000 tons. Two 6-in. and two 3-in. guns will be carried, and an armour belt of nickel steel, together with other protective plating, will be provided. The propelling machinery, consisting of twin-screw vertical triple-expansion engines, capable of developing 350 i.h.p., is being built by Messrs. Hawthorn, Leslie and Co., Limited, and is expected to give a speed of 12 knots to the vessel, which is the first to be launched from the builder's Armstrong Yard for a Foreign Powar. The original contract, placed in 1913, was cancelled on the outbreak of war and a new one was placed in July of last year.

SOME TESTS ON A TWO-STROKE CYCLE OIL-ENGINE.*

By PROFESSOR E. A. ALLCUT, M.Sc., of the University of Toronto.

(*Concluded from page* 682.)

APPENDIX I.

THE CALORIFIC VALUE OF OIL.

IN all experiments involving the use of liquid fuels, accurate measurement of the calorific value of the fuel is a matter of great importance. The best method of measuring this property was carefully considered in connection with the preceding series of tests. The sample of oil was taken by means of a glass tube extending from the top to the bottom of the tank in each instance, so that a vertical section of the contents was obtained.

This sample was tested in four different ways:

(1) By a chemical analysis from which the calorific value could be calculated,

(2) In a Mahler bomb calorimeter,

(3) In a Parr calorimeter,

(4) In a special calorimeter described below.

The disadvantages of chemical analysis are that the process is long and complicated, demands great care, a skilled chemist, and special apparatus.

The Mahler bomb calorimeter is probably the most accurate apparatus for determining calorific values, but in the case of oil, the quantity burned (about 0·5 gramme) is so small that serious inaccuracies are liable to creep in. High pressures of oxygen must be used, and the fuel is burned under constant volume conditions. In the present series of tests trouble was experienced at first in obtaining consistent results, until it was found that in some cases the thermometer accidentally touched the side of the bomb, and a special attachment was made to control its position.

The Parr calorimeter is convenient for commercial testing, but on account of the smallness of the sample and other difficulties, consistent results are not at all easy to obtain.

It was considered that if an oil calorimeter could be designed on a similar principle to that used in the Junkers and Sargent calorimeters, well known and widely employed in gas calorimetry, some of these difficulties might be overcome and a closer approximation to the actual conditions of practice obtained. One method of doing this has been described by Moss and Stern*, but suitable burners were not available in the present series of tests, and the fuel to be tested was more difficult to evaporate and inflame than were the petrol, benzene and paraffin used in their apparatus. It was considered that the use of an incandescent surface of refractory material inside the calorimeter body (as used in the "Bonecourt" surface combustion principle) might provide a means of overcoming some of the difficulties, and a calorimeter was designed and constructed on these lines.

The body of the calorimeter, Fig. 8, consisted of a copper vessel 14 in. long and 4 in. diameter, packed with calcined magnesite, the oil-burner being introduced through an orifice in the bottom. The oil and air mixture was intended to burn on the surface of the refractory material, and the products of combustion returned to the bottom through water-jacketed tubes to an outlet in the usual way. The top and bottom of the calorimeter were made removable to facilitate cleaning of the tubes if and when necessary. The water was passed through the jacket at a constant rate, its weight, inlet and outlet temperatures being recorded.

The oil-burner first used was of the Wallsend-Howden type, consisting of two jets delivering tangentially into a whirling chamber before issuing from the final orifice. The air supply was delivered from a small Roots blower.

The pressure necessary for atomising and delivering the oil was obtained by means of an air vessel, Fig. 9, supplied with water from the town main. The air compressed in this vessel was used as a transmitting medium to apply pressure to the oil in the measuring bulbs. A suitable arrangement of valves permitted either of the two bulbs to be used at will, and a stand pipe and funnel enabled one bulb to be filled while the other was delivering a measured quantity of oil to the calorimeter. Accuracy of measurement was obtained by filling each bulb to a mark on the upper glass tube and noting the time taken for the level to fall to a similar mark on the lower tube. Care was taken in design and construction to avoid air and oil pockets.

This method of measurement was abandoned at the conclusion of the experiments described in Appendix II, as it was found that atomisation conditions suitable for calorimetric work were difficult to control with a high pressure jet. It was then decided to adopt the principle of introducing air or some other gas into the oil jet, so that good atomisation and proper admixture of combustible and supporter of combustion might be obtained.

For this purpose an atomizing sprayer of the type used in medical work was obtained, the oil suction pipe being connected by rubber tubing to a supply tank mounted on weighing scales, Figs. 8. Air was first supplied under pressure, but although the refractory material inside the calorimeter was heated to redness before turning on the oil-jet, satisfactory combustion could not be obtained. An oxygen tank was then connected up to the air jet through a needle-valve, by means of which the pressure could be regulated to any desired extent. This failed to give satisfaction until extra air was supplied to the outside of the jet by means of a motor driven blower. After a number of experiments had been made, it was found that preliminary heating of the refractory material could be dispensed with, the oxy-air-oil jet being easily ignited by a piece of burning paper. If the air and oxygen supply were properly regulated, a perfectly smokeless exhaust could be obtained, and Table II gives the results obtained in five successive tests made on the fuel oil used for the engine trials described in this paper.

Corresponding tests were made on the Parr and Mahler bomb calorimeters, and the results obtained on these instruments are also given. It is considered that the Mahler bomb results are too high.

As the air pressure necessary for complete combustion is small (about 0·3-in. water pressure), it is advisable to use a gauge of the differential type. In the apparatus used, excessive air pressures caused losses by blowing back air and oil past the burner, but this could be avoided by improved construction or by automatic regulation of air and oxygen pressures.

The experimental apparatus described and illustrated had hand regulation throughout, and the drop of calorific value observed in test No. 15 is apparently due to reduced oxygen supply.

A further attempt was made to run on air only,

Fig. 8. DIAGRAM OF OIL CALORIMETER.

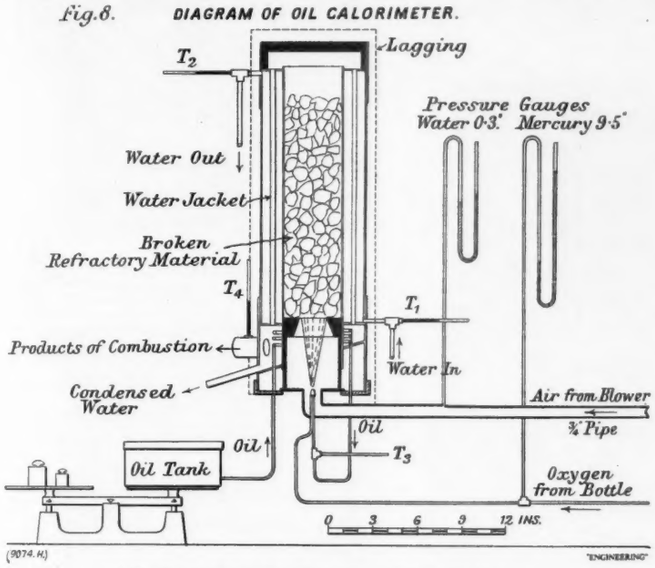
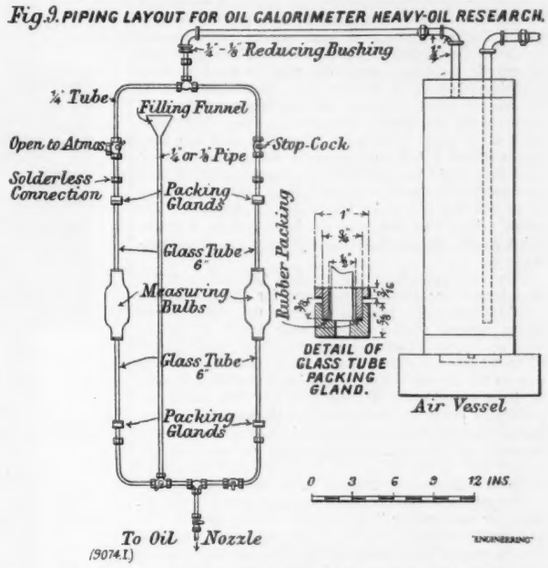


Fig. 9. PIPING LAYOUT FOR OIL CALORIMETER HEAVY-OIL RESEARCH.



T_1. Temperature of cooling water entering calorimeter.
T_2. Temperature of cooling water leaving calorimeter.
T_3. Temperature of oil entering calorimeter.
T_4. Temperature of products of combustion.

TABLE II.—*Tests on Oil Calorimeter.*

Test No.	11	12	13	14	15	16
Duration, minutes	28·45	28·62	23·80	26·73	26·62	20·08
Weight of oil, lb.	0·265	0·265	0·221	0·265	0·265	0·132
Temperature of oil, deg. F.	87·2	89·0	89·1	96·0	96·3	77·1
Temperature of air, deg. F.	70·1	71·4	72·8	76·2	77·1	71
Rise of cooling water, temperature, deg. F.	14·21	13·98	14·16	14·54	14·48	15·14
Pressure of oxygen, in. mercury	9·51	9·50	9·83	9·80	9·87	9·60
Pressure of air, in. water	0·3	0·36	0·4	0·38	0·4	0·3
Exhaust gases volumetric composition—						
CO_2	12·55	12·72	11·65	13·87	13·65	10·93
O_2	8·22	8·00	9·12	6·50	6·48	5·46
CO	0·0	0·0	0·0	0·0	0·0	0·0
N_2	79·23	79·28	79·23	79·63	79·87	83·61
Air used per lb. oil, lb.	16·4	16·1	17·7	14·8	15·2	19·8
Oxygen used per lb. oil, lb.	1·02	1·02	1·01	0·97	0·87	—
Total heat developed, B.Th.U.	5,262	5,264	4,395	5,252	5,168	2,584
Cal. value of oil (higher) B.Th.U. per lb.	19,850	19,860	19,880	19,810	19,500	19,500
Cal. value of oil (lower), B.Th.U. per lb.	18,715	18,725	18,745	18,675	18,365	18,365

Test Results on Mahler Bomb Calorimeter.

Higher calorimeter value—B.Th.U. per lb 20,034
" " " " .. .. 19,947 } Mean value 20,046.
" " " " 20,158

Test on Parr Calorimeter—19,850 B.Th.U. per lb.
(Mean of two tests.)

* Paper read before the Institution of Mechanical Engineers on Friday, May 22, 1924. Abridged.

* ENGINEERING, December 15, 1922. Also Harwood in ENGINEERING, September 28, 1923.

using the same pressures as were found satisfactory with oxygen. The air for atomising was obtained by running water into a large tank and displacing the air under a pressure of 9 to 10 in. of mercury.

On account of the limited volume of the tank, insufficient time was available to obtain quite steady conditions before readings were commenced, but the results of this test are given in Table II, test 16. The exhaust was slightly hazy, so that combustion was probably not quite complete. The low cost and greater flexibility available with the use of oxygen, however, make the use of that gas preferable wherever possible.

APPENDIX II.

Flow of Oil Through Small Orifices.—In selecting nozzles for an oil calorimeter, the choice is restricted by the fact that with apparatus of a reasonable size only a limited amount of heat can be carried away by the cooling water in a given time. For this reason the nozzle employed must be able to pass a small quantity of oil at a uniform rate, and this involves the use of small orifices. In the Wallsend-Howden type nozzle previously referred to, the diaphragm holes were made 0·0405 in. diameter, and the final orifice 0·016 in. diameter, these being the smallest sizes that could be drilled. On experimenting with a measured quantity of oil, it was found that the escape of oil was far too rapid for practical purposes. The outlet orifice was therefore partly closed by a screw-down needle valve, but this method proved unsatisfactory.

The next procedure was to drill the outlet orifice to a larger size and to substitute for the diaphragm a thin brass sheet with a punched or drilled orifice in its centre. These orifices were made of various sizes and were tested under oil pressures varying from 53 to 12 lb. per square inch. The method of testing was to fill the left-hand measuring bulb (Fig. 9) with oil to a given mark and to time by stop-watch the passage of a known volume of oil through the orifice. From these readings a pressure-time curve was drawn in each case, and from these curves the rates of discharge and the coefficient of discharge were calculated for each orifice at the various pressures employed.

The punched orifices were made in brass 0·013 in. thick by perforating it with a fine sewing needle. At first, orifices similar to No. 4, Fig. 10, were obtained, but by restricting the depth of perforation and rotating the needle, orifices Nos. 3, 17 and 11 were obtained.

The shape and size of the outlet end of each orifice were obtained by means of a photo-micrographic apparatus set to magnify 100 diameters. The image of the orifice was thrown on the ground-glass focusing screen, traced on paper, and the area obtained by planimeter. This area divided by 10,000 was the actual outlet area of the orifice. The kind of image obtained is shown in the photograph of drilled orifice No. 15A (Fig. 11).

The drilled orifices were made in brass sheets 0·015 in. thick, the smallest obtainable having a diameter of 0·00438 in. These were preferred to the punched orifices, as they were more easily reproducable and more uniform in section, but tests were made on both.

The oil used was that employed in the oil-engine tests, having a specific gravity of 0·850, and the following viscosity characteristics as obtained on the Saybolt viscosimeter* :—

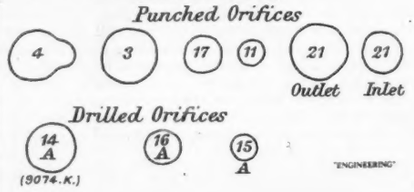
Temperature. Deg. F.	Time of Efflux for 60 cc. Oil. Secs.
120	38·7
100	40
85	42
70	48

Discharge tests at pressures of 53 lb., 42·5 lb., 32 lb., 22 lb., 17 lb. and 12 lb. per square inch respectively were made on each orifice, and the actual rates of discharge (cubic inches per second) for each orifice are plotted in Fig. 12. Coefficients of discharge for each orifice and pressure are plotted in Fig. 13, and it is evident that the curves for both drilled and punched orifices have similar characteristics, but that the coefficients of discharge for punched orifices are lower than those for drilled orifices. It should be noted that these orifices have lengths varying roughly from 1½ to 3½ diameters.

Figs. 14 and 15 are curves connecting orifice areas with fluid discharged for drilled and punched orifices respectively, each curve corresponding to a constant pressure. It will be noted that for orifices having areas less than 0·00003 sq. in., the coefficient of discharge decreases very rapidly with the area. For drilled orifices between 0·00003 sq. in. and 0·00005 sq. in., the coefficient keeps approximately constant, but for punched (convergent) orifices the coefficient continues to rise until an area of 0·00007 sq. in. is reached.

Orifice No. 21 was intended to supply another point on the punched orifice curves, but becoming stopped up during a test, it was opened out on the discharge side, making a divergent orifice, Fig. 10, so that the results are not comparable with those obtained from the other orifices. The curves obtained are similar to those plotted for the other orifices, but the discharge coefficients are higher than those for the convergent punched orifices.

Fig.10. MAGNIFICATION 40 DIAMETERS. (⅔ ORIGINAL SIZE)



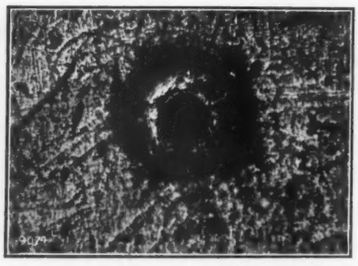


FIG. 11. ORIFICE 15A.

Fig.12. DISCHARGE OF OIL FROM SMALL ORIFICES.

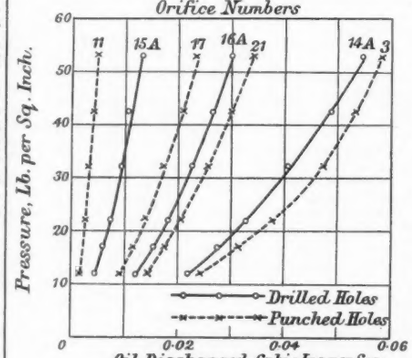


Fig.13. DISCHARGE OF OIL FROM SMALL ORIFICES.

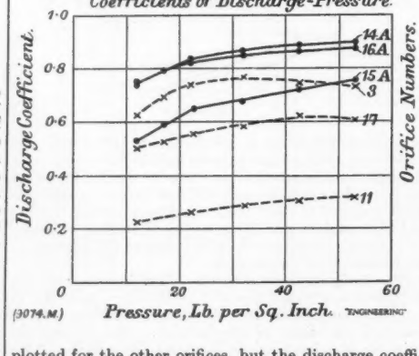


Fig.14. DISCHARGE CURVES FOR DRILLED ORIFICES.

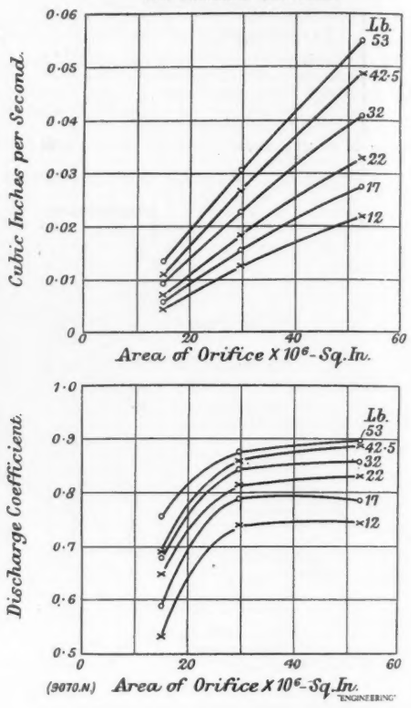
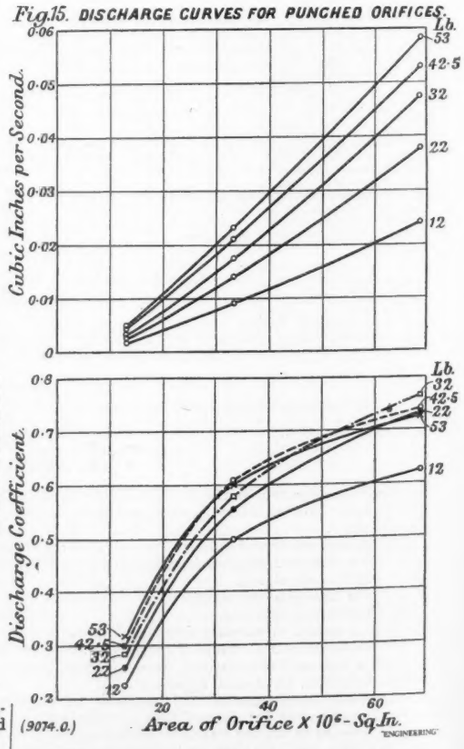


Fig.15. DISCHARGE CURVES FOR PUNCHED ORIFICES.



APPENDIX III.

ATOMISATION TESTS.

In the combustion of liquid fuels atomisation plays an important part, and with the successful application of the burner described a few experiments were made to ascertain the extent and character of the atomisation obtained under different conditions. It had been observed that the atomising agent (oxygen or air) produced the best results in this case, when a pressure of 10 in. of mercury was used. Tests were therefore made with pressures of 10 in., 7·6 in., and 4 in respectively.

The method of testing was to pass glass slips rapidly across the oil jet at a distance of about 6 in. above the nozzle. The slips were then placed in an air-tight case, to avoid evaporation or contamination, and were then examined successively under a microscope with a magnification of 30 diameters. Characteristic photographs

* See United States Government Specification for Lubricants and Liquid Fuels (1924).

ATOMISATION TESTS OF FUEL-OILS.

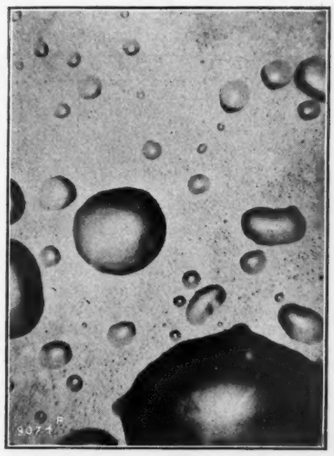


FIG. 16 A.

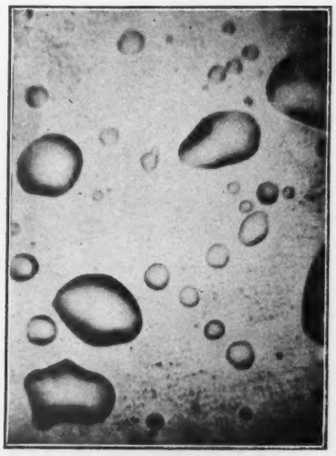


FIG. 16 B.

Pressure of Oxygen—4 In. Mercury. × 30 Diam.

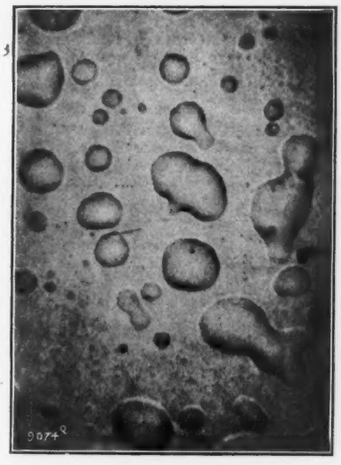


FIG. 16 C.

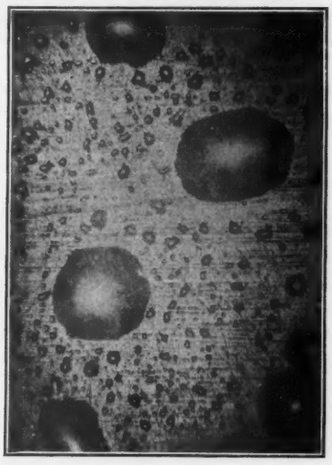


FIG. 16 D.

Pressure of Oxygen—7·6 In. Mercury. × 30 Diam.

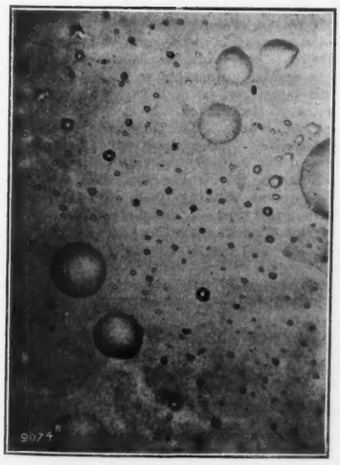


FIG. 16 E.

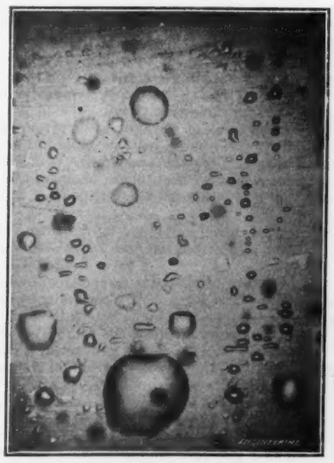


FIG. 16 F.

Pressure of Oxygen—10 In. Mercury. × 30 Diam.

of the results are shown in Fig. 16, but many more observations were taken to obtain average results.

From the photographs, it is evident that the splitting up is by no means uniform, the drops being of various sizes. Fig. 16, D. E. and F, however, show considerable scattering in very small drops—a phenomenon entirely absent from A, B and C. It would appear, therefore, that a pressure of 4 in. of mercury (2 lb. per square inch) is insufficient to produce pulverisation into the very small drops obtained at the higher pressures. Also that the higher pressures are only partially successful in this respect.

It is interesting to note that the diameters of these small particles vary from approximately 0·0005 in. to 0·003 in. These figures, of course, do not indicate the diameters of the original spherical drops, but form a convenient basis of comparison for different methods of atomising.

The larger drops are still more important, for upon their size depends the possibility of obtaining complete combustion. Although these vary considerably in size, it is possible to get some idea of their mean diameter by going over the entire surface with a microscope and by measuring the diameters of the largest globules in the field of view.

This was done for the three pressures selected, and the results obtained are given in the following table :—

Pressure.		Diameter of Largest Spot.	Average Diameter of Large Spots.
		Inch.	Inch.
10 in. Mercury	(A)	0·0175	0·0098
	(B)	0·0205	0·0088
7·6 in. Mercury	(A)	0·0260	0·0114
	(B)	0·0250	0·0102
4 in. Mercury	(A)	0·0265	0·0130
	(B)	0·0300	0·0153

From these figures it appears that there is a fairly definite relationship between the sizes of the oil globules produced and the atomising pressure.

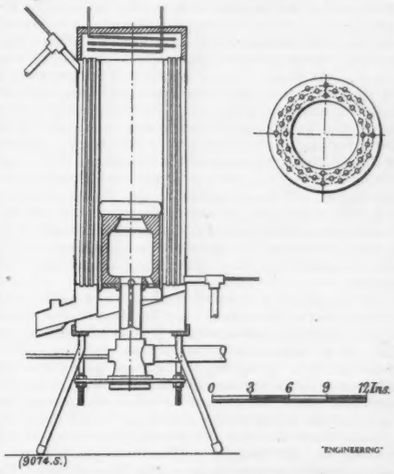
Further experiments along these lines would probably throw more light on the exact nature of this relationship and upon the factors that influence the atomisation of liquid fuels generally.

APPENDIX IV.

DESIGN AND CONSTRUCTION OF CALORIMETER.

As a result of the tests described in Appendix I, a modified design of oil calorimeter was prepared, the details of which are shown in Fig. 17.

Fig.17. CALORIMETER FOR HEAVY OILS.



The combustion chamber is moulded in carborundum or some other heat-resisting material, and is enclosed in a casing of spun copper, to the bottom of which a flange is brazed. This casing is shaped to form a sliding joint with the inner body tube, and to leave an air space between the combustion chamber and the water jacket. This allows the combustion chamber to become sufficiently hot, but intercepts the heat radiated from its outer surface. A hole is made in the flange and combustion chamber to allow the oil to be lighted while the burner is in position.

The casing, combustion chamber, and refractory filling are supported by a tube screwed into the brass flange at one end and into the burner casting at the other. This casting has a glass window at the bottom, through which the conditions of combustion can be observed, and it also has a flange which rests upon the supporting bridge piece. The latter is held in position by two studs screwed into the stand, so that by adjusting the nuts the position of the combustion chamber relative to the jacket may be altered at will, and also, by taking off the nuts, the whole of the inside of the calorimeter may easily be removed. The air pipe screws into one side of the burner casting, and the oil and oxygen pipes enter through the other side.

The calorimeter body is of the usual water-jacketed

type, containing forty-eight tubes, and the outlet water pipe is brazed to it at an angle, as shown, to ensure the jacket being full of water and the outlet thermometer always immersed.

The top cap is removable and contains a coil by means of which heavy oils can be preheated and their viscosity reduced before they reach the burner. This is unnecessary with light oils.

The bottom cap is so shaped that the water of condensation can run freely to the outlet, a lip being formed in the latter to enable the water temperature to be taken if necessary. This cup is soldered to the inner body tube to form a water-tight joint, but by melting out the solder, the bottom cap also can be removed to facilitate tube cleaning if and when necessary.

The whole of the body is surrounded with 1 in. thickness of heat-insulating material, and the various connections are made as in the case of the experimental apparatus shown in Fig. 8.

CLAY CONVENTION AT BUXTON.

(*Concluded from page* 683.)

Two interesting papers by L. S. Theobald, B.Sc., A.R.C.S., and A. T. Green, entitled "Observations on the Elimination of Carbonaceous Matter from Fireclay Bricks," and "An Investigation of the Changes taking place during the Industrial Burning of Fireclay Bricks," were also taken as read, for want of time. The first of these papers described the results of heating portions of green bricks to temperatures up to 900 deg. C. at various rates, in many cases maintaining the temperature constant for a definite period, the pieces being then broken across and examined. The materials used were of the same kind as those used in a previous investigation, viz., Stourbridge clay, a Yorkshire fireclay, and a Scottish fireclay, but chiefly the first-named. The results obtained with Stourbridge briquettes heated in a small gas-fired muffle furnace were briefly as follows:—(1) Oxidation, judged by the appearance of the salmon-pink colour characteristic of small amounts of ferric iron, commences at 550-580 deg. C. Decomposition of the carbonaceous matter, as judged by the slight change in the shade of dark grey, commences in the neighbourhood of 500 deg. C. (2) Oxidation of the carbonaceous matter increases as the time taken to reach a given temperature is increased, and with the time of holding at that particular temperature between the approximate limits 600-900 deg. C. (3) With a rate of increase in temperature of 75 deg. C. per hour up to 550 deg. C., the approximate times required to burn out the carbonaceous matter under the conditions cited above are:—(*a*) From 550 to 600 deg. C., 7·5 hour and at 600 deg. C., a period of eight hours. (*b*) From 550 to 750 deg. C., 2·7 hours, and at 750 deg. C., 3 to 4 hours. (*c*) From 550 to 900 deg. C., 4·7 hours, and at 900 deg. C., two hours.

In this connection, however, the heat work which is performed on the pieces by reason of the higher temperatures in (*b*) and (*c*) must not be overlooked, as this all contributes to the elimination of carbonaceous matter.

At temperatures above 600 deg. C. and to the limit investigated in this work, viz., 900 deg. C., the oxidation of carbonaceous matter is followed by the formation of a bluish white ring which develops into a yellowish core occupying the former position of the black core in the interior of the test-piece. This does not take place when care is taken to prevent the temperature rising above 600 deg. C. before all the carbonaceous matter is eliminated, even on subsequent heating at 900 deg. C. The test piece shows a characteristic salmon pink colour throughout. This change appears to be the result of the reducing action of the carbon on the iron compounds present. These yellow cores may have but little practical bearing on the quality of the completely burned bricks. It would be well-nigh impossible to prevent the formation of this yellow core under industrial conditions.

The Yorkshire fireclay bricks gave results which showed no great difference in behaviour from the Stourbridge specimens as regards the times required for removing the carbonaceous matter. No yellow core is produced with this clay, which burns to a cream colour. This accords with the smaller percentage of iron in the Yorkshire fireclay.

The Scottish firebricks did not show any strong development of black cores, and fewer tests were made with them.

In the case of the Stourbridge specimens, the true specific gravity reached a minimum at about 600 deg. C.—probably in connection with dehydration of the kaolinite—and then increased from 600 deg. C. to 900 deg. C. Maximum porosity is generally supposed to occur at about 750 deg. C., but the authors obtained maximum porosity at 600 deg. C. by continued heating at that temperature.

For the second paper a study was made of bricks drawn during four burnings, at different times. Two burnings were of Stourbridge bricks and the other two were Scottish fireclay bricks, the latter being burned in a gas-fired continuous kiln. The two lots of Stourbridge firebricks were burned in a coal-fired continuous kiln and in a round kiln respectively. Tabulated data and graphs show the results of tests for true specific gravity, true percentage porosity, apparent percentage porosity, and loss on ignition. Colour was also noted. The authors summarise very briefly as follows:

(1) Samples of firebricks have been withdrawn from four kilns at various stages during the firing, and data concerning them have been determined in the laboratory.

(2) The true specific gravity data indicate chiefly (*a*) the change in the kaolinite molecule progressing from about 450 deg. to 570 deg.; (*b*) the polymerisation of the alumina molecule about 950 deg.; and (*c*) some considerations respecting the vitrification range.

(3) The range of maximum porosity and the other facts concerning the vitrification range are shown by the true and apparent porosity determinations.

(4) The "loss on ignition" data give an indication of the commencement of the dehydration of the kaolinite and allows a time-factor, during which water vapour is being evolved from the clay substance, to be obtained.

(5) The determinations of volume contraction, though necessarily inaccurate, substantiate the conclusions appertaining to the vitrification range, based on the specific gravity and porosity data.

(6) Visual observation of the specimens gives valuable information concerning (*a*) the elimination of carbonaceous matter; (*b*) the appearance of "iron" specks and blotches; (*c*) the colour changes taking place during burning; and (*d*) the vitrification of the products.

(7) The data of water-smoking agree with those formulated from a previous laboratory experimentation.

(8) A consideration of the time factors required for doing the necessary heat-work in the kilns is appended.

The last paper read was one by J. Mitchell and W. B. Mitchell on "Laboratory Furnace for High Temperatures." This describes a new type of electric furnace depending on the use of a metallic resister in the form of molybdenum wire wound round a suitable core such as a small tube made of alundum cement. The metal wire is protected from excessive heat and from oxidation by enclosing the heating tubes and some of the lagging in a gas-tight container filled with inert gas. The inert gas is supplied by a specially designed apparatus, in which ammonia gas (derived from an aqueous solution) is decomposed by means of a small subsidiary furnace which has an independent circuit. Some details as to current, supply, &c., are given in the paper. With an alternating current supply and a special transformer, the furnace can be taken up quite uniformly, each step of 5 volts representing about 100 deg. C. rise of temperature. On the 65-volt step the furnace attains a temperature of 800 deg. C.

This type of furnace is adapted, not only for testing refractories, but also for other laboratory uses, such as metal melting and the standardisation of pyrometers at the high temperature points.

PUNT PLOUGHING TACKLE.

MESSRS. JOHN FOWLER AND CO. (LEEDS), LIMITED, ENGINEERS, LEEDS.

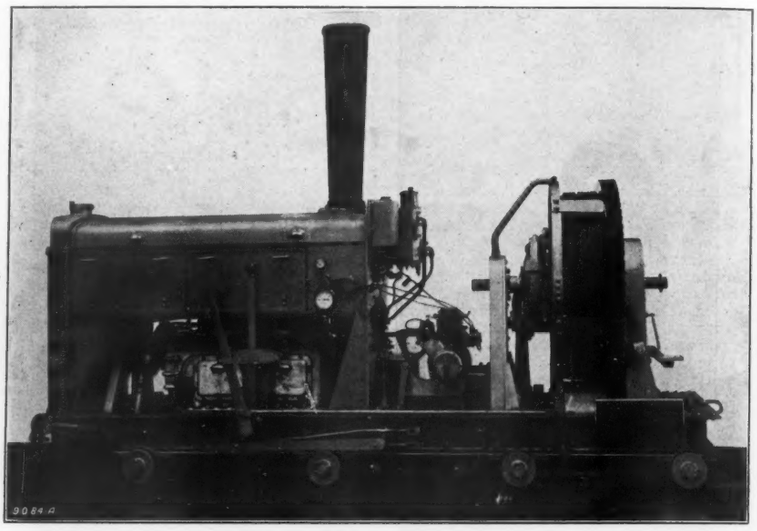


FIG. 1. ENGINE AND WINDING DRUM.

PUNT PLOUGHING TACKLE.

THE ploughing tackle which we illustrate on this and the opposite pages, has been designed by Messrs. John Fowler and Co. (Leeds), Limited, for use on the sugar plantations in British Guiana. The conditions on these plantations are quite exceptional, as they are for the main part on level alluvial flats almost at water level. The fields are intersected by canals which serve the double purpose of draining the land and acting as highways, and in the method of ploughing adopted with the Fowler apparatus these canals are utilised to carry punts containing the engine and winding drum for cable ploughing. Two punts are used on parallel canals, and the plough is operated between them in a manner similar to that employed in ordinary cable ploughing between two land engines.

It will be evident that one of the problems involved is the prevention of the punt being canted over by the tension in the cable, and this is met by the provision of a special adjustable boom attached to the punt. This boom can be seen in Figs. 2 and 3, and is so designed that it can be accommodated to various heights of bank. The punt is moved along the canal by means of a hand winch, which can be seen in operation in Fig. 3.

Referring now to Fig. 1, it will be observed that the engine and winding drum are carried on a girder frame, and form a complete unit running on rails. The latter are mounted on the bottom of the punt, and the object of this arrangement is to enable the engine unit to be moved fore and aft to make room for the plough when it is desired to transport the latter to a new position. Shackles passing over the wheel and through holes in the rail are supplied to lock the unit in the working position. A Ricardo crosshead engine is employed, the design being modified to adapt the engine to alcohol, as this fuel is readily obtainable from the molasses which form a by-product in the process of sugar-extraction. The engine has an unusually high compression ratio on this account, and is fitted with an exhaust muff on the induction system. The exhaust pipe branches after it leaves the cylinders, part of the gas being by-passed through the muff, and the remainder passing through a silencer and thence up the chimney. The output on alcohol is between 80 b.p. and 100 b.p. The engine is started up on petrol by means of a small air-cooled, two-stroke Precision motor, and is switched over to alcohol after a short period sufficient to warm up the induction system. The Precision engine is fitted with a kick

PUNT PLOUGHING TACKLE.

CONSTRUCTED BY MESSRS. JOHN FOWLER AND CO. (LEEDS), LIMITED, ENGINEERS, LEEDS.

FIG. 2. VIEW SHOWING MOORING BOOM AND CABLE RUN TO PLOUGH.

FIG. 3. PLANT IN OPERATION IN BRITISH GUIANA.

starter of substantial proportions, which can be clearly seen in Fig. 1. It drives the main-engine starter shaft through a totally enclosed worm-reduction gear. The starter shaft is fitted with a series of fibre friction discs, which can be engaged with a corresponding series of grooves cut in the flywheel periphery. A foot lever, working against a spring, is provided for bringing the disc into contact with the flywheel. Pump circulation is provided for the main-engine cooling water, in conjunction with a large radiator and cooling fan, and the lubrication is of the dry-sump type with the well-known special arrangement adopted in the Ricardo engines for the crossheads. The various controls, both for the main and starting engines and for the winding drum, are all arranged on the near side of the unit, as viewed in Fig. 1. The ignition and throttle levers for the main engine can be seen mounted on the side panel adjacent to the pressure gauges, and the control levers for the starting engine are mounted directly to the right of the main engine controls.

The drive is transmitted to the winding drum through a plate clutch and two-speed gear-box located behind and below the level of the starting engine, and the final drive is by spur gearing on to the winding drum, the wheel mounted on the latter being clearly seen in the illustration Fig. 2. The winding-drum, which carries 500 yards of steel-wire rope is fitted with a coiling head mounted on the drum axle between the inner bracket and the drum proper. The drum is also provided with a foot brake which is mounted on the outer bracket. The change-speed lever can be seen in front of the engine terminating in a knob, and the lever in front of this is for operating the ploughing clutch. The petrol and oil tanks are mounted on the front panel, and the main fuel tank on the opposite side of the engine from that shown in the figure.

THE ESTIMATION OF PHOSPHORUS IN THE PRESENCE OF VANADIUM.*

By G. WATSON GRAY, F.C.S., and C. DURHAM GARBUTT, F.C.S.

MANY methods have been published describing the estimation of phosphorus in the presence of vanadium, but in the hands of the present authors none have proved satisfactory. Some have been unreliable, while others have proved too long and tedious. After many experiments a method has been devised which has been found reliable and at the same time reasonably quick.

Two grammes of the finely powdered alloy or other material to be tested are dissolved in 50 cubic centimetres nitric acid of 1·2 specific gravity in a 600 cubic centimetre squat beaker, and after the action has ceased 5 cubic centimetres of hydrochloric acid are added and the solution digested for ten minutes. It is then evaporated to dryness to render any silica insoluble and taken up with 25 cubic centimetres of hydrochloric acid. The solution is diluted, filtered, and the paper washed free from vanadium and iron by means of water containing 100 cubic centimetres of hydrochloric acid per litre. The insoluble matter is burnt off and treated with hydrofluoric acid and the residue fused with nitre mixture, the melt dissolved in water, the crucible cleaned with hydrochloric acid, and the solution obtained added to the original solution and evaporated to dryness.

Forty cubic centimetres of hydrochloric acid are now added, the beaker covered and the solution allowed to simmer for ten to fifteen minutes, or until no more chlorine is evolved. At this stage all the vanadic acid will be reduced. This is necessary and important, as if any vanadic acid remains unreduced all the phosphorus will not be obtained by the subsequent ether separation. The solution is now cooled and transferred to a separator with hydrochloric acid of 1·105 specific gravity. An equal volume of ether is now added, and the whole shaken vigorously for two minutes and allowed to separate. The acid solution containing the vanadium together with the whole of the phosphorus and arsenic is then tapped off into the original beaker. The ether solution is given a wash with 5 cubic centimetres of hydrochloric acid of 1·105 specific gravity, and this is added to the larger portion. The acid solution is re-treated with ether to remove any traces of iron still remaining, and then warmed gently until the dissolved ether is expelled, and the acid solution is again evaporated down until it is pasty. The sides of the beaker are washed down with hot water and 6 grammes of citric acid added. At this stage the solution should be perfectly clear. It is transferred to a 300 cubic centimetre tall form beaker, washed in and cooled. The bulk of the solution should now be about 120 cubic centimetres. Excess of ammonia and further ammonia equal to 25 per cent. of the bulk of the liquid is added. This will make the volume of the solution about 160 cubic centimetres; 10 cubic centimetres of magnesia mixture are now added drop by drop, stirring vigorously, and the stirring continued for ten to fifteen minutes, the solution being left to stand overnight. The precipitate is filtered off on a suitable paper, the beaker washed on with water containing 10 per cent. ammonia and 2 per cent. ammonium nitrate and the paper washed free from vanadium. If arsenic be present in the sample, the whole of it will be in this precipitate. The precipitate is dissolved in hydrochloric acid, and the arsenic removed as sulphide by hydrogen sulphide. The filtrate from the arsenic precipitate is boiled to expel H_2S, oxidised with nitric acid, a little ferric chloride added, and the iron and phosphorus precipitated with ammonia, filtered and dissolved into a 200 cubic centimetre flask with nitric acid, and precipitated with molybdate as usual.

* Paper presented to the Iron and Steel Institute, London, May, 1925.

FORM EFFECTS AND FORM RESISTANCE OF SHIPS.*

By Mr. W. G. A. PERRING.

IN order to test the streamline theory a form was made around which the pressure variation could be measured. The form adopted for this purpose was a sharp-ended symmetrical surface of revolution. It was derived mathematically by assuming a sink and source distribution obeying a cubic law and imposing upon this distribution a uniform stream velocity. The case worked out was three dimensional, and, because of mechanical limitations, the model made was 8 ft. long with a ratio of length to maximum diameter of 8 to 1. A model was made of wood and fitted with brass conical ends and had a shaped steel bar let in on the under side into which the tappings were taken. These tapping points, $\frac{1}{16}$-in. diameter, communicated to gauge glasses by means of $\frac{1}{4}$-in. internal diameter lead tubing. The model was mounted upon a steel streamline strut placed about 6 in. aft of amidship, and had a second strut 18 in. aft of the end, and connected to it by means of a small coaxial circular tube. These struts, besides supporting the model and keeping it directionally stable, served to bring the tubes from the pressure points to the surface. In all twenty-four pressure points were arranged along the model, and these were connected up to "change-over" valves that enabled these points to be connected up to a nest of gauge glasses. By means of a vacuum tank the water level was brought into the gauge glasses, and during a run down the tank eight of the pressure points were put into communication with these glasses. Upon the level becoming stationary the valves were closed. The zero levels in still water were checked at the end of the run, after the heights had been recorded, by again opening the valves. In this way the pressure curve for the form was obtained. To ensure greater accuracy a second method of obtaining the pressure changes was also adopted. In this, instead of measuring the head directly, the pressure point was connected to one end of an inverted U tube, whilst the other end of the tube communicated with a "static" tube. By using petrol (coloured blue) as a second fluid in the upper limb of the tube, a magnification of about 5 to 1 was obtained, owing to the density difference between the petrol and the water. Speed of advance was taken by the usual distance and time contacts of the carriage, and in some of the experiments by means of a Pitot tube. The necessity of having a stabilising strut at the after end and a means of conveying the pressure tubes to the surface rendered it impossible to have a tapping point nearer than 8 in. from the stern. A few experiments were, therefore, conducted with the model proceeding stern first. The forward end was then well clear of strut interference, and, apart from this effect, reproduced the true conditions of the stern.

The results of these experiments and the theoretical pressure curve for a non-viscous streamline motion are given in Fig. 1. These results are for the model run with its central axis 5 ft. below the surface of the water. The results for the theoretical curve are for a body moving forward in an infinite fluid. The integral of this curve in a fore and aft direction must necessarily be the resistance of the body as it moves forward, if each radial plane experiences the same pressure distribution. For the theoretical curve, the resistance is zero, because it is obtained upon the assumption that the fluid is non-viscous. The other curves have been integrated, and agree approximately with the resistance, but the method is very susceptible to small changes. The experiments afford a general confirmation of the streamline theory and show clearly the inability of the water to give up its acquired energy as the body moves forward. There is a tendency for the pressure to recover and for a zone of slightly positive pressure to exist just at the rear. At the higher speed there is a tendency also for the zone of suction in the after-body to increase.

It is not the intention to discuss, in the present paper, questions relating to the boundary layer, and turbulent portions of the flow set up in fluid friction, nor to deal in any way with the inner structure of the flow around plank and prismatic bodies—but to deal only with the features likely to produce form effects. Perhaps it is necessary to point out that experiments have shown that in the immediate neighbourhood of a smooth surface there is a very thin layer of fluid in a state of viscous motion, while outside this layer the fluid is eddying and in turbulent motion. Also, hydrodynamical theory indicates that a body moving forward will experience a pressure variation similar to that indicated in Fig. 2; and were the body brought to rest by imposing on the system a uniform velocity in the reverse direction to that in which it is moving, the fluid would then be moving in a series of so-called streamlines having a definite formation.

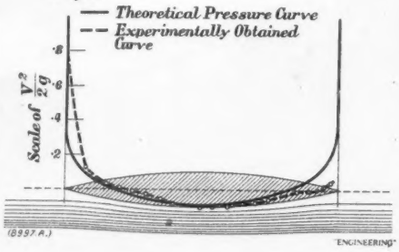
* Paper read before the Institution of Naval Architects, London, on April 2, 1925. Abridged.

A general analysis of all plank results made by Mr. G. S. Baker in a paper before the North-East Coast Institution in 1915 showed plank results to obey approximately the following law suggested from dimensional considerations:—

$$R = A \rho V^2 f \frac{V L}{\nu}.$$

where R = resistance, A = wetted surface, ρ = density, V = velocity, L = length, ν = ratio of linear dimension model to ship. Subsequent experiments have been analysed upon the same theoretical basis, and the analysis shows that there is no serious departure from the general law. Depth effect can show itself in two ways. There may be a direct effect necessitating an additional function $f \frac{V D}{\nu}$ in the general law, and a second effect that may be indirectly due to the longitudinal edges. Increase in the ratio of depth to length

Fig. 1.



will render the effect of the edges or of the edge and free surface, as the case may be, less and less important. Minor differences are always possible due to differences in the nature of the surface or in the manner of its preparation; the usual surfaces for experimental model work are paraffin, varnished shellac, or painted or polished metal, and these are always perfectly smooth. Despite all precautions, however, differences do occur which are imperceptible to the touch or the eye, and as yet no satisfactory measure of "smoothness" has been suggested. No plank can be made without thickness, and for this reason there will be a certain amount of "body or form" effect—the beam, too, may influence the edge effect considerably, since it may result in a wide flat edge, a sharp knife-like edge, or some intermediate form of keel. Body effect is rather difficult to define, or even allow for.

A series of models were made to determine how the "form effects" depend upon shape when this is varied so that girth and sectional area distribution along the length remain unaltered. All the models were made of wax and to a standard length of 16 ft. The arrangements of towing and recording resistance and speed were identical with those adopted in ordinary model test work; but for the lower speeds where the resistances to be measured were small, a spring giving a very open calibration was used to maintain an open record of resistance. Six models have been made with rectangular section and circular bilges, all having a curve of areas identical with the mathematical form around which the pressure variation measurements were made. The maximum sectional area of these forms, however, was 18·9 per cent. less than the circular form tried. The circular section enclosed the maximum cross-sectional area for a given girth and this area was reduced in order to retain the same girth. A supplementary model, of wax with semi-circular under-water form, reproducing the parent model was made and run in the free surface of the water to compare it with the results given by these other similar forms. The details of all the models tried are given in Table I. Model 632 differs from 676 in that the half-beam and draught of the one become the draught and half-beam of the other respectively. Models 632 and 676B represent the extremes in $\frac{B}{D}$ ratio tried. The results are shown in Fig. 2, where $\frac{R}{A \rho V^2}$ is plotted to a base of $\frac{V L}{\nu}$. The area is the total wetted surface. Upon this diagram is also shown the calculated skin-friction curve, using the "O" values of Dr. R. E. Froude, so that differences from this skin-friction curve should indicate approximately the "form effect" and any slight wave-making effects that are present.

The results for models 632 and 697A are practically identical, and agree also with the results for model 630A, the model with semi-circular under-water section. These three models give a curve lying some 12 per cent. above the estimated skin-friction curve for speeds up to the point where wave-making resistance becomes noticeable, and the curves begin to show an upwards tendency. Model 697B shows the same characteristic but results in a curve only some 10 per cent. above the estimated skin-friction curve. Model 676A, however, resulted in a curve that over a considerable speed range lies below the estimated skin frictional curve and indicates one or two possibilities. It may be the "O" values of R. E. Froude overestimate the frictional resistance, but an alternative possibility is that, although the skin friction deduced from plank experiments gives results obtained where the conditions approximate to two-dimensional flow, this flow may not be two dimensional. It is conceivable that model 676A so lends itself to the flow outwards and downwards, that the resulting resistance is less than that estimated from plane surfaces. Theoretically, too, it might be argued, from the fact that the pressure variation is less, and therefore the velocity changes introduced are less in a three-dimensional case than in the two, the skin friction would also be less; but it is difficult to obtain a shape that will lend itself to flow in three dimensions. The results for the other two models, 676B and 697C, are rather peculiar, for with these models the experiments have resulted in two curves for each form that approach each other as speed increases. The experiments defining these curves were run on two consecutive days, and were arranged so that the results of the first day were confirmed by the experiments on the succeeding day. The individual experiments sometimes resulted in a "high" spot being obtained, and sometimes in a "low," and to all appearances the condition during all the experiments was the same. It is suggested the explanation of this rather striking result is due to some peculiarity in the flow being set up around these models. Two types of flow seem possible, and conditions present in the starting

TABLE I.—DETAILS OF MODELS TRIED. ALL MODELS 16 FT. LONG.

Number of Model.	Maximum Beam.	Maximum Draught.	Maximum Radius Bilge.	$\frac{B}{D}$	$\frac{L}{B}$	Remarks.
	In.	In.	In.			
632	24·0	7·71	2·0	3·11	8·0	NOTE.—All models have water-lines and profile, similar to the curve indicated in Fig. 1, for the streamline form deduced from mathematical considerations.
697A	20·28	9·01	0·67	2·25	9·47	
697B	19·10	9·55	0·59	2·00	10·04	
697C	18·00	10·2	0·81	1·77	10·67	
676A	15·4	12·00	2·00	1·28	12·48	
676B	14·0	13·70	4·31	1·02	13·71	
630A	24·0	12·0	Semicircular section	2·00	8·0	

TABLE II.

Number of Model.	Length.	Maximum Beam.	Maximum Draught.	$\frac{B}{D}$	$\frac{L}{B}$	Remarks.
	Ft.	Ft.	In.			
636A	16	24	7·71	3·11	8·0	Normal ships' lines having same area distribution, and midships section, as model 632. Also run at 2 in. lighted immersion.
636B	16	24	7·71	3·11	8·0	0·48 sq. ft. of area were cut at the bow from model 636A and lines faired in to this cut-away ending.
636C	16	24	7·71	3·11	8·0	A further 0·63 sq. ft. was removed from 663B, this time at the stern, and line again faired into new ending.
643A	16	4	18·5	0·216	48·0	Plank form with shaped profile having same girth distribution as previous torpedo set.

FORM EFFECTS AND FORM RESISTANCE OF SHIPS.

Fig. 2. **RESULTS FOR SERIES OF TORPEDO FORMS**

(For Dimensions of Models see Table I)

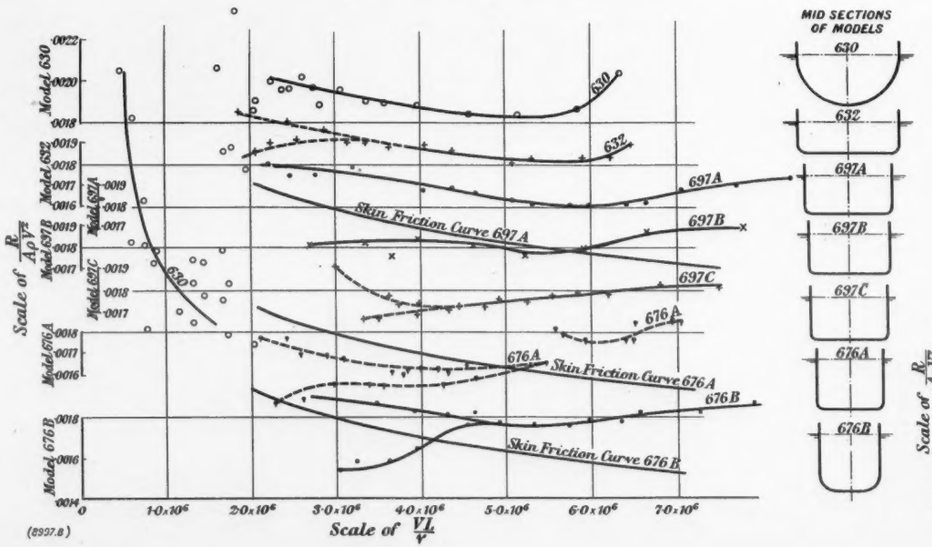


Fig. 3. (For Dimensions of Models see Table II)

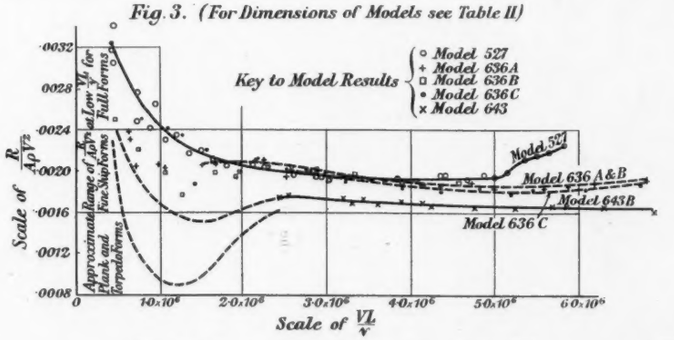
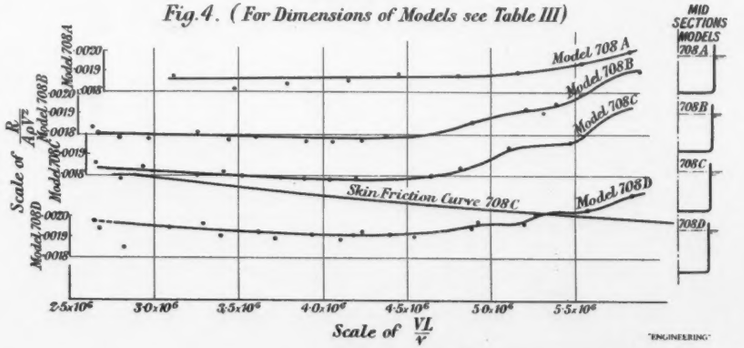


Fig. 4. (For Dimensions of Models see Table III)



up and acquiring a steady speed sometimes set up the one and sometimes the other of these two types of motion.

The experiments have emphasized the necessity in all model work of conducting the tests at a sufficiently high speed, and with a model sufficiently long to result in a $\frac{VL}{\nu}$ for the model of at least $3{\cdot}0 \times 10^6$. This means that for a 16-ft. model in water at 55 deg. F. the minimum speed should be 143 ft. per minute, but usually the flow steadies up and the resistance records become reliable for speeds above 110 ft. per minute when dealing with this size model. With plank forms at low values of $\frac{VL}{\nu}$ it is possible to obtain very small $\frac{R}{A\rho V^2}$ values, while at still lower $\frac{VL}{\nu}$ values the $\frac{R}{A\rho V^2}$ curve rises rapidly; with many of the models discussed in the present section similar results have been obtained at the low $\frac{VL}{\nu}$ values, and some of the experimental spots obtained during these low-speed tests are indicated in Fig. 2.

The results given previously relate to approximately torpedo forms, and to link these to other model work two further forms were made—models 636 and 643. Model 636 was a normal ship with lines drawn out so that the curve of areas was identical to the torpedo forms tried, the water-line at the bow, however, was somewhat finer. The girths suffered modification, but the total wetted surface was the same as in the previous forms. The lines so prepared presented no abnormal feature and had nothing to distinguish them from ordinary ship sections. The second form, model 643, maintained a similar curve of sectional areas as in the previous set, but the section was reduced to a maximum beam of 4 in., at the same time keeping the girth distribution along the length. This resulted in the model having a "markedly" curved profile, with a maximum depth of 19 in. at the centre. Owing to the small beam, and the resulting small displacement, this model had to be run upon a horizontal gate-frame carried at each end by vertical frames on knife-edges; and it could not trim or sink under the hydrodynamical forces set up. The results of these tests are shown in Fig. 3, together with some results obtained on slight modification of model 636, Table II indicating the nature of the modifications made. The results for model 636 agree almost exactly with those for the forms 630, 632, and 697A of the previous set, there being no more than 3 per cent. difference between them. An analysis of a very large number of other models has been made upon the same basis, and usually when these model lines are good they lie near this same curve or within 2 or 3 per cent. of it, seldom falling below. But for the results of the remaining models of the previous set, and particularly of model 676A, it might have been assumed the true "form effect" could be accounted for by some 3 or 4 per cent. augment of the velocity, or more directly by the addition of 10 to 15 per cent. to the calculated skin friction made by the usual methods. The results for model 643A are almost identical with those obtained for a 16-ft. plank run at the tank in December, 1914. The results shown make no allowance for the wave-making, but it is hoped to discuss this item in more detail upon another occasion.

TABLE III.

Number of Model.	Length.	Maximum Beam.	Maximum Draught.	$\frac{B}{D}$	Wetted Surface.	Dimensions.		400-ft. Ship. Displacement.	Prismatic Coefficient.
						Beam.	Draught.		
	Ft.	Ft.	In.		Sq. ft.	Ft.	Ft.	Tons.	
708A ..	16	24·96	12·96	1·926	53·9	52·0	27·0	11,200	0·70
708B ..	16	24·0	13·48	1·781	54·3	50·0	28·08	11,200	0·70
708C ..	16	22·8	14·19	1·607	54·5	47·5	29·56	11,200	0·70
708D ..	16	21·6	14·97	1·443	54·9	45·0	31·2	11,200	0·70

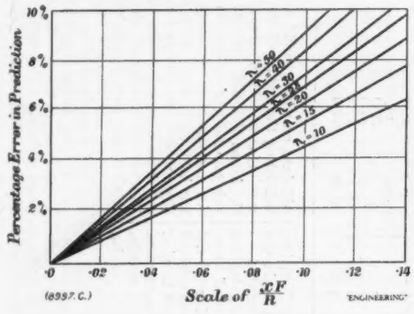
In order to investigate further the form effects of normal ship bodies, a series of models were run in which the displacement and curve of sectional areas were maintained whilst the beam and draught ratios varied. The girth and wetted area were not the same for all of these models, but varied only a very small amount from one to the other. The dimensions of the four forms tried are given in Table III, together with the features common to each of them, and the results obtained are shown in Fig. 4, where $\frac{R}{A\rho V^2}$ has been plotted to a base of $\frac{VL}{\nu}$.

Again, to compare these results with the previous set given in Fig. 2, and with plank experiments, the skin friction deduced from Froude's "f" values has been indicated upon the diagram. Model 708A, a model having a beam to draught ratio slightly on the small side, gave a result about 10 per cent. above the calculated skin friction curve, which previous analysis had led one to expect. Upon reducing the beam and increasing the draught, thereby still further reducing the ratio of beam to draught, a curve only some 5 per cent. above the skin frictional estimated curve was obtained, and upon a further reduction this same curve was maintained.

Model 708D, however, gave results higher than even

the first model tried, it being 12 to 13 per cent. above the skin friction curve. These results can be harmonised with the previous series if it be assumed in passing from model 708A to model 708D a two-dimensional type of flow has been trying to establish itelf as the form was narrowed. That is, in models 708A, 708B and 708C, three-dimensional flow predominated and as the beam diminished the velocity changes diminished. But in passing to model 708D the sides become more wall-like, and the curves at the end sections flatten. This form did not lend itself to easy three-dimensional flow, only partially doing so. With the flow becoming more two-dimensional in character, the resistance increased because the pressure changes for such a flow are greater than are the three-dimensional ones. This reasoning is admittedly hypothetical, but it accounts for the differences that "form" introduce. By fixing the water-lines, and increasing the draught, one would expect the wave-making to be less serious; if, however, the previous argument is correct and the pressure produced are actually greater because the character of the flow is becoming two-dimensional, then there should be no reduction in the wave-making, and this actually was found to be the case, the models being purposely run at higher speeds to explore this point. With still further reduction of beam the resistance of the models expressed as $\frac{R}{\Delta \rho V^2}$ will go on increasing until a maximum is reached, after which the resistance will fall back again to somewhere approaching the "plane" skin friction curve, the form itself becoming "plane like."

Fig. 5. **GRAPH SHOWING PERCENTAGE OVER ESTIMATION OF SHIP RESISTANCE INTRODUCED BY AN UNDER ESTIMATION OF THE MODEL FRICTIONAL RESISTANCE**



One set of experiments upon Model 527 demonstrated the influence of the shoulder in the forward body. This particular model had a prismatic coefficient of 0·797, but had a very fine run, and a comparatively short length of entrance with the water-line at the bow making an angle of 30·5 deg. to the middle line plane. At low speeds the eddies at the shoulder were very marked, and as already stated, these disappeared as the speed increased, and a divergent wave commenced to form at this point. It was pointed out in Section 4 when dealing with the experiments upon the torpedo forms, that in the case of these models when working at small values of

$$\frac{V L}{\nu} (= 0{\cdot}8 - 1{\cdot}6 \times 10^6),$$

the type of flow set up resulted in low values of $\frac{R}{\Delta \rho V^2}$, but that within this range instability occurred, and the results were useless for practical application.

With a fine ship form, model 636, it was not possible to set up this type of flow, and the results obtained, although still unstable, gave relatively higher $\frac{R}{\Delta \rho V^2}$ values. With the full bow form the results were still higher, and the limits of the three types are indicated in Fig. 3. It should be noted that in the case full-bowed model 527, as soon as the speed was sufficiently high for the divergent wave to form at the shoulder, the $\frac{R}{\Delta \rho V^2}$ obtained with this model agreed very nearly with that for the torpedo forms, and continued to do so until wave-making became serious. Another interesting point to notice is, that the $\frac{R}{\Delta \rho V^2}$ curve obtained at low speeds is similar in shape but smaller in ordinate to that obtained with a sphere.

In applying model results to ships the process is to estimate from the model resistance the portion due to wave-making (the residuary resistance) by deducing from the total measured resistance the calculated "skin" frictional portion. The Froude Law of comparison is applied to this residuary resistance, and when added to the estimated ship frictional resistance gives the total resistance. To arrive at the model resistance the estimated skin friction for the model is calculated, using generally the frictional data of Dr. R. E. Froude. These data only approximately apply to ship forms, and the results already given in this and the previous parts of the paper indicates the differences between plank and prismatic bodies. These differences for want of a more intimate knowledge have been bracketed together into the one term "Form Effects," and in the ordinary methods of application are considered to obey the "Froude" law of comparison, and are included with the wave-making in the residuary resistance. This may introduce a slight error.

Using approximate figures, the percentage error in the predicted total ship resistance has been calculated for various values of $\frac{x F}{R}$, and these errors are shown graphically in Fig. 5. The errors gets increasingly unimportant as speed increases, and slight errors in the skin and wave resistance of models should not lead to any serious discrepancy in the predicted ship resistance; and provided we were certain of the extension of our skin friction data, our predicted resistance should never differ greatly from the actual.

The experiments outlined in the present paper, while not sounding a "final" note on the subject of form effect, do show approximately its importance so far as ships are concerned, and the investigations, as was earlier shown, indicate that the error introduced by misallotment of a certain portion of the eddy resistance, when predicting the resistance of a full-sized ship from model results, is not serious. The fact that some shapes lend themselves more readily than others to the flow of water around them is not surprising, but that this should be so to the extent of 15 per cent. to 20 per cent. in the case of two forms so much alike as 632 and 676 was unexpected.

FORMATION OF OIL-FIELD EMULSIONS.

THE range of the term "emulsion" is too indefinite to admit of exact estimates of the quantities of oil which leave the well in an emulsified condition. But it is stated in No. 2683 of the Investigation Reports of the United States Bureau of Mines, drawn up by D. B. Dow, that at least 20 per cent. of the petroleum produced in the mid-Continent and in the Gulf Coast fields require treatment before marketing, and that in California more than 10 per cent. of the oil is treated by one process alone. The presence of water always means the potential formation of emulsion; practically no oil field is free from water, and the emulsion trouble becomes more serious with the age of the field.

Water and crude oil are generally considered immiscible. A pure mineral oil may dissolve 0·0003 per cent. of water, but in commercial oils that percentage may rise considerably. Mechanically crude oil may carry water both in true emulsions, when water drops are covered with a microscopic film of oil, and in suspension when drops of the one medium are suspended in the other. True emulsions can only settle after the destruction of the protective film. Suspensions may settle by gravity, so far as the viscosity of the oil permits. In the oil field emulsified mixtures are known as "cut oils." In the tank separation into three layers may take place, oil, concentrated emulsion and free water. The concentrated emulsion is called "B.S." (which is interpreted into bottom settlings or basic sediment), a term as unfortunate as cut oil and many other terms of oil nomenclature, particularly because bottom sediments designate also any heavy sediments.

Emulsification is provided by agitation and may be produced in the oil sand. Thus a hole bailed dry was found after a time to be full of emulsified oil, as if "cutting" had taken place before the oil reached the well. On the other hand it required a pressure of 1,000 lb. to force an oil emulsion through ½ in. of 200 mesh sand, and the sand, acting as a filter, seemed indeed to break up the emulsion. It would therefore appear that the emulsion can not be formed far back in the sand except when it can reach the well through crevices. Generally emulsification seems to take place in the well or tubing or in the pipe lines above ground. When there is little water, all the water may be emulsified; with water quantities above a certain percentage, little emulsion is formed. In Baku severe emulsion trouble was mitigated by raising the water percentage in the well to 20; in Lima, Indiana, the addition of salt water had the same effect. In new wells flowing under gas pressure the gas agitates and emulsifies the oil, and the emulsification seems to take place chiefly at the flow nipple where the pressure release is greatest and almost explosive. A 3-in. tube in a working barrel was installed in a flowing well of Oklahoma; the oil delivered from the pump then became clear, whilst the oil from the casing around the tubing remained "cut." Elsewhere the agitation due to the gas has been decreased by keeping up the back pressure on the well. This can be done by the aid of separators and traps above the ground in which oil gas and water separate before the pressure is released. The typical separator in use at El Dorado, Arkansas (described in a United States Bureau of Mines Report of 1922 by H. W. Bell and J. B. Kerry) consists of seven joints of 10-in. pipe with oil and gas risers at each end. The oil riser at the higher end of the separator is formed by two 4-in. vertical nipples, 6 ft. high, each having at the top a four-way "T" connected to chokes, from ⅜ in. to 1 in. in size. These chokes are required in high-pressure wells to lessen the flow and to reduce the water and sand trouble. The separation of gas and oil is accomplished in the last risers. The whole separator is inclined (being 6 ft. higher at the end further away from the well), and there are lateral 6-in. lines for bleeding off water and sand. Another type of trap, much used in the Ventura field, California, consists of three joints of casing, arranged in parallel above one another and cross-connected by 2-in. lines; the middle joint is connected to the well at one end, and oil, gas and water flow under a back pressure.

Where air lifts are used to promote oil production, as in the Gulf Coast field, very stable emulsion are frequently formed. In some places, however, as in the east pool of the West Columbia field, the cut oil rapidly breaks down; this oil is of slightly higher gravity and is produced a little warmer than the permanent emulsion of the north pool. The use of swabs is also apt to set up emulsification, by the stopping at high speed of oil and water between swab and casing. The valves in the pumping system, both for suction and delivery, may be the cause of emulsion troubles. That the oil is forced through the ports at high velocity is not so serious as are the leakage actions, which increase with the wearing of the valves, plungers, &c., by the sand. There may also be churning in the well when there is not enough oil to fill the barrel. In the casing and tubing emulsification further arises from the "whipping" of sucker rods and from leaks. Finally, agitation and turbulence in the pipes above ground, due to the condition of the line, sharp corners, sacks, &c., and to entrainment of gas may be the cause of emulsification in a fairly clear oil. Prevention of the evil is commonly cheaper than the subsequent cure by dehydration.

BRITISH NON-FERROUS ALLOYS CHEMICAL STANDARDS.

THE standard steels, issued by Messrs. Ridsdale and Co., the pioneers of the movement for the establishment of a British Bureau of Standards, are now well known to the metallurgical chemist and are serving a very useful purpose in the industrial laboratory. The first of a series of non-ferrous standards has just been issued and this fresh enterprise on the part of the organisers will be viewed with considerable interest by all analysts. The new standard, termed "White Metal 'A'," is a lead-base alloy. Its percentage composition is as follows: Lead, 82·58; antimony, 12·05; tin, 4·64; copper, 0·34; iron, 0·07; bismuth, 0·03; arsenic, 0·06; zinc, 0·08. As was the case with previous standards, the new alloy has been prepared with great care and special precautions have been taken to ensure that the material is homogeneous.

A large number of chemists have co-operated in the analysis of the white metal, and these represent referee analysts, manufacturers, buyers, Government Departments, and the Bureau of Standards of the United States. The standard is available for sale and may be purchased from the Organising Headquarters, British Chemical Standards, 3, Wilson-street, Middlesbrough. The usual certificate giving the names and the results of analysis of collaborating chemists is furnished with all samples, and the latter are supplied in 50, 100 and 500 gramme quantities.

DIRECTORY OF PAPER MAKERS, 1925.—Any trade work of reference which has appeared regularly each year for nearly half a century requires no further endorsement of its utility as a real aid in business. A volume with such a record is the Directory of Paper Makers of the United Kingdom for 1925, published by Messrs. Marchant, Singer and Company, of 47, St. Mary Axe, London, E.C.3, at a price of 5*s.* net. Within its compass of 280 pages are contained alphabetical lists of manufacturers in the United Kingdom, with many particulars following the names in each case. Paper makers' representatives in London and the provinces are mentioned and lists of mills are supplied. The different kinds of papers made are stated in alphabetical order, after which follow the names of manufacturers. The trade designations used by paper makers are grouped under two sections, actual watermarks and trade names which are not actual watermarks, while the paper sizes, paper trade publications and other general information contained in the work should ensure its continued support.